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A JOURNEY TO TASHIRAK IN SOUTHERN TIBET, AND THE EASTERN APPROACHES TO MOUNT EVEREST.

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ATTENTION during the last few years has been focussed more and more upon the Himalayas; and now that the poles have been reached it is generally felt that the next and equally important task is the exploration and mapping of Mount Everest. It cannot be long before the culminating summit of the world is visited, and its ridges, valleys, and glaciers are mapped and photographed. This would perhaps have already been done, as we know, but for the war and the lamented death of General Rawling. This piece of exploration has been his life's ambition. May it yet be accomplished in his memory!

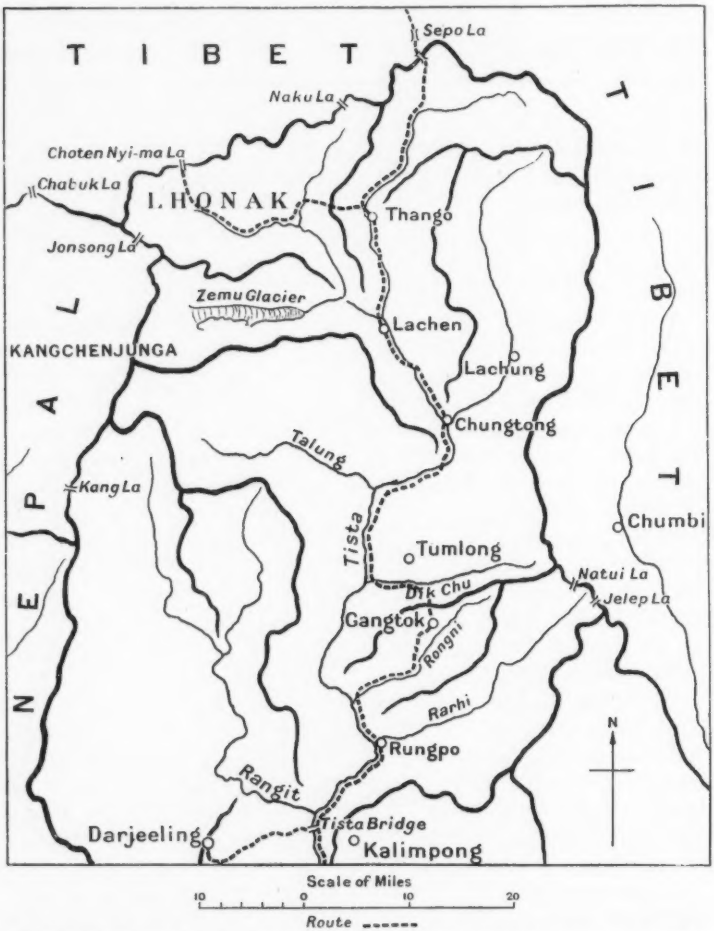
Being a member of General Rawling's proposed expedition before his death, and having studied the problem of reaching Everest, I give the following brief account of a journey to Tashirak undertaken in 1913 for the purpose of reconnoitring the approaches to Everest beyond the Sikkim frontier in Southern Tibet.

Excluding the idea of reaching the mountain through Nepal by the Kosi Valley (the shortest route) on account of the political difficulties, which are not likely to be removed, the only approach lies through Sikkim from Siliguri or Darjeeling by the Tista Valley to the Sikkim–Tibet frontier, thence from Kampa Dzong, making a right-angle turn to the west behind the main range of the Himalayas, taking Mount Everest from the east from Tashirak, or from the north from Tingri.

A photographic survey by aeroplane is also possible, because a direct flight and return could be made from the plains of India without the necessity of landing in the mountains. The difficulty of landing urged against the aeroplane does not in the case of Mount Everest exist, since the mountain is so very close to the plains. A greater difficulty is found in the high winds of Tibet. A development of air work in connection with Tibetan travel that suggests itself is the use of man-lifting kites. These are portable, and with the strong steady winds of Tibet could raise

an observer 500 feet in the air, a height which would give good observation over the plains.

The line of approach for an expedition through Sikkim is comparatively easy. The distance to the snows is short compared with other parts of



Sketch-map to illustrate the first part of Major Noel's paper: the principal mountain ranges are shown by heavy black lines

the Himalayas, where the mountains have much greater depth. A road, practicable part of the way for bullock carts and the rest for pack-animals, leads from the foothills through the entire length of the country to Kampa in Tibet.

The excessively heavy rainfall turns many travellers away from Sikkim, but this disadvantage does not apply to the northern districts of the country, which enjoy the typical dry climate of Tibet. The monsoon clouds have generally deposited their moisture after passing the line of the Zemu glacier–Pawhunri–Chumalhari.

Transport and supplies are a somewhat difficult problem unless the conditions of travel in Sikkim are known by previous experience. More than one expedition led by competent travellers has come to grief in that country. The difficulties can be diminished firstly by avoiding Darjeeling and its officialdom at all costs and taking the Siliguri–Tista valley road, and secondly by purchasing and owning one's transport animals instead of relying upon coolie hire from stage to stage. Bullock carts can be used as far as Gangtok, and ponies or mules from Gangtok to Kampa Dzong. Thence onwards in Tibet the road is good everywhere for yaks.

The entry into Tibet can be made either from the upper Lachen Valley by the Sepo La, 16,500 feet, the easiest but longest route, or from Lhonak by the Choten Nyima La, 18,500 feet, or the Jongsong La, 20,000 feet, through the corner of Nepal to Tashirak: the shorter and far more interesting although the more difficult route.

The approach to Everest from the north would be best made from Tingri, a route practicable for yaks but requiring, of course, the sanction and co-operation of the Tibetans. The approach from the east would lie through Lhonak by Tashirak and the Arun valley. An intricate mass of lofty mountains, hitherto unmapped, intervenes between Lhonak and the Arun valley; and it is the geography of these mountains that is the subject of special interest to the explorer who wishes to approach Everest from the east.

Lhonak, that country that Hooker had never been able to reach, and that he had left blank on his map, was first visited by Mr. White in 1897, who entered it by The La, 17,400 feet, from the Zemu glacier. Lhonak, so different from the rest of Sikkim, is indeed a delightful and beautiful valley. To feel the charm of Lhonak, to become imbued with that wish to return again and again that it particularly inspires, one must have first undergone the discomfort of the long journey through the heat and steam and torrential rains of the jungles of the foothills; one must have felt the disappointment of the views of the snows hidden so persistently in cloud and mist; one must have scrambled through the deep ravines of Sikkim with their dense forests and rampant leech-infested bamboo thickets. Then, after these days of hard travelling are over, one crosses the pass over the dividing range and steps in one moment into a totally different land. A high plateau-land of broad open valleys and rounded snow-capped hills, a land of luxuriant pasturages, of yaks and sheep and perpetual sunshine—that is Lhonak.

Lhonak can also be reached by the ravine of the Zemu river from

Lachen, some two days' march up a rough path; and it is only on reaching Teble, where the two main valleys of the Langpu and Naku join, that the typical Lhonak scenery of open broad valleys and rounded hills is first met. From Teble, generally the site of a Tibetan encampment, one can survey both valleys. In the Naku valley one looks over beautiful pasture land, where most of the yaks are to be found, up to the broad, bare saddle of the Naku La. On the right rise the fine snow peaks of Chumiomo and Lackenkang, throwing some large broken glaciers down into the valley below. The Langpu branch leads up to the horseshoe of giant mountains of Kangchen and Jongsong. At the head of the valley lies Zanak, the furthest point to which the Tibetan encampments extend at the threshold of the snows beneath the Jongsong Pass. The pass, the only link between Lhonak and Nepal, looks a stiff proposition indeed; and one can well sympathize with Sarat Chandra Das, the first explorer to have crossed this way, in his difficulties described quaintly and delightfully in the volume of travels: 'A Journey to Lhasa and Central Tibet.'

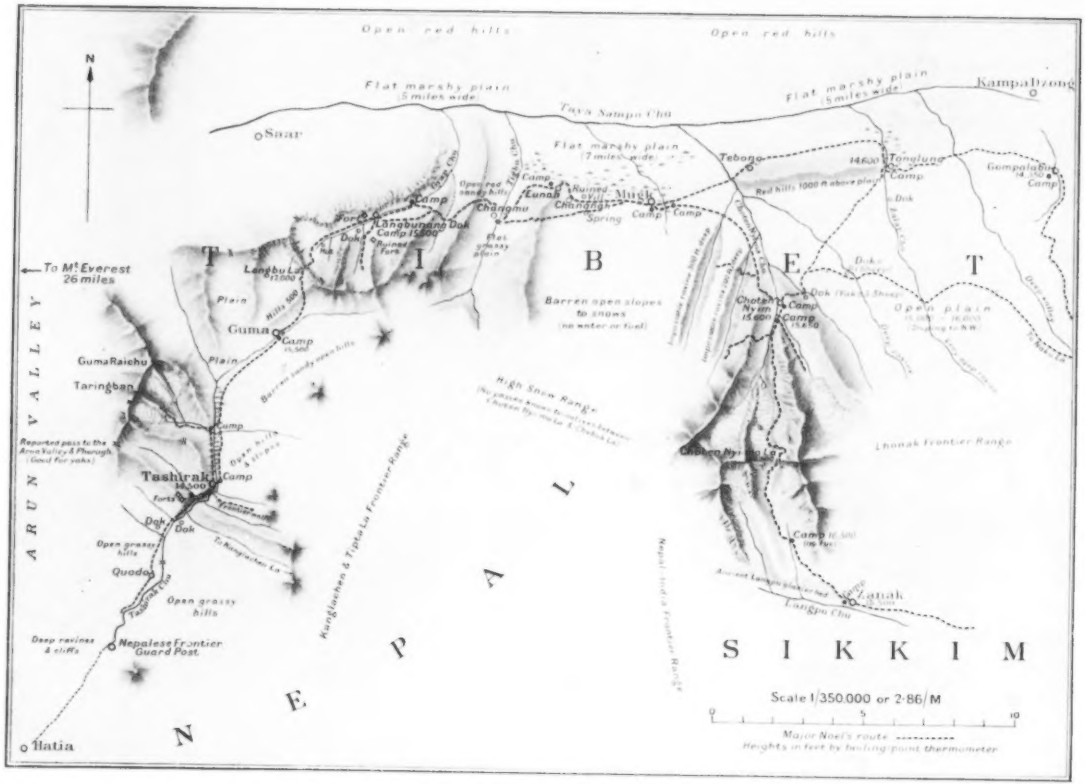
From the Jongsong peak a high range branches off in a westerly direction, sending south the spur that separates the Tambar from the Arun Valley. Little is known of these mountains, and only one pass and a difficult one, the Chabuk La, is known to cross them. The Nepalese traders use only the Jongsong–Choten–Nyima or Jongsong–Naku La routes to reach Kampa Dzong in Tibet, which adds to the belief in the height and difficulty of crossing this branch range and frontier barrier between Nepal and Tibet. Several travellers, including Sir Joseph Hooker, have thought Mount Everest was visible from the tops of the hills in the upper Lachen Valley, but this is not so, because the lofty peaks beyond the Jongsong effectively mask the view of Everest.

Beyond the point where the Kanglachen Tipta La spur is detached to the south the range was crossed by Sarat Chandra Das in 1881 by the Langbu La. He reported the general direction of the range to be north-west to south-east, the hills only low, and the Langbu La to be free from snow in the summer. But the Langbu La is a long way west of the Jongsong La, and a great barrier of mountains intervenes. Sarat Chandra Das, giving unfortunately only a rather vague account of his journey, described seeing "the lofty Pherugh mountains" from the summit of the Langbu La, and Pherugh is the district of Mount Everest.

Thus it would appear that in order to reconnoitre the eastern approaches to Everest, the best plan would be to make for the Langbu La from Lhonak. Then, according to the Indian Government map of Nepal, one could proceed by Tashirak down into the Arun Valley, and crossing the Arun, proceed directly west up the valleys leading to the foot of Everest. But these surmises, based on Sarat Chandra Das's account and also on the map of Nepal, proved quite wrong. Instead of the Langbu La giving access to the Arun Valley, I found that it was separated from that valley

MUGK VILLAGE, TIBET

CAMP AT MUGK



SKETCH-MAP OF EASTERN APPROACHES TO MOUNT EVEREST

by yet another mountain barrier. Our knowledge of the country further west is even more scanty, because such Pandit travellers as have been there journeyed only up the two valleys of the Arun and the Kosi, and were unable to ascend any of the branch valleys that lead up to the glaciers of Everest.

The country north of Everest is drained by the Tingri River, which flows for a considerable distance east until it empties into the winding Arun. The Arun itself appears to occupy a narrow defile at the Tibet–Nepal frontier, when it cuts through the main chain of the Himalayas between Everest and Kangchenjunga.

The valley of Tingri and Shekar Dzong had been traversed in 1708 by the Capuchin Friars, who had established a mission at Lhasa and who communicated with that place from their Nepalese headquarters at Katmandu by Nilam, crossing the mountains by the Thung La. However, no mention has been made by any of them of their having seen Mount Everest. Even the explorer M. H., who came through Nepal by the Dudh Kosi Valley and the Pangu La, 20,000 feet, and followed a line along the limit of habitation, did not approach near enough to observe even the glaciers of Mount Everest.

At the conclusion of the Lhasa expedition, Rawling and Ryder passed by Shigatse and surveyed the Tsampo Valley and the mountains forming the watershed between the Tsampo and the Tingri rivers. But owing to the lateness of the season and the length of the journey they had to accomplish to Rudok, they were unable to deviate sufficiently far to the south to reconnoitre the Tingri plain and the northern approaches to Mount Everest.

Owing to the impossibility of obtaining permission to travel by the open, easy road *viâ* Kampa Dzong, I decided to enter Tibet from Lhonak *viâ* the Choten Nyima Pass, and to march unobserved as far as possible, avoiding the villages by a high-level route to the Langbu La and Tashirak. The spring of 1913 was spent in arranging plans with my two Bhutia servants, Adhu and Achum Bhutia, and learning something of the Tibetan language. I started from Siliguri, where I was met on July 5 by Adhu, who had come down from Gangtok with two mules. We packed the kit on the mules and set off the same day for Sivook, a hot march through the Terai forests at the foot of the Himalayas. We carried two small A-shaped tents, blankets and bedding, a small tin box of necessary instruments, a camera, a few medicines and arms and ammunition for the party. Otherwise we were entirely free of impedimenta, obtaining supplies locally.

Gangtok is reached after a six days' hot and tiring trek through the steaming forest of Lower Sikkim. Nor can one enjoy the beautiful scenery during this monsoon period, when the clouds and mists hang low and the rain pours incessantly. After resting two days at Gangtok we pushed on rapidly for the pleasant and healthy elevations of Lachen in

Upper Sikkim. The plan was now to continue the journey with yaks. The yak caravan would carry a month's supply of satu (barley meal) and tea, etc., for the party, and had orders to proceed to Tebong in the Taya Sampo Valley in Tibet, which, according to Sarat Chandra Das's account, lay near the exit from the Choten Nyima Pass. It was to wait there without attracting the attention of the Tibetans while I crossed with a few coolies by the Choten Nyima Pass to Tebong, thus avoiding Kampa and Tinki Dzong, where the Tibetan officials resided. The mules accordingly were sent back to Gangtok, and we started for Thango. Here two men with the yaks and supplies struck out for the Sepo La at the head of the Lachen Valley, while I branched off to the west, crossing the Lugnak La into Lhonak.

The ascent to the pass is easy, although snow covered except in the months of August and September; and one is cheered on the ascent by the prospect of crossing the mountains into the delightful Lhonak Valley. A rapid descent down a stony couloir from the bleak windy crest of the pass brought us to a pretty little emerald lake, whose banks were overgrown with luxurious grass on which a number of yaks were grazing. A short way beyond we reached the camping-ground of Chabru, where a cave formed by a huge overhanging rock made a comfortable shelter for the night. Next morning we proceeded down the valley, fording the Naku Chu and camping at Teble, a delightful spot commanding unequalled views of the broad open valleys, walled by rounded snow-capped summits. The sky is ever a clear blue and the air is cold and crisp and dry.

The road hence up the Langpu Branch of the Lhonak Valley reveals particularly grand scenery. Soon after leaving Teble and traversing the extensive plain that stretches some miles to the west, a defile is passed where an ancient moraine from the south encroaches and forces the river to impinge against the northern hillsides. Then a bend to the north-west immediately brings to view a remarkable panorama of the Zemu mountains and the high peaks that rise at the head of the valley and form the central knot where the Tibetan, Sikkim, and Nepalese watersheds meet.

The countryside is broad, open and sandy, and the stream trickles over a wide bed, breaking up into small channels with many boulder-strewn islands between. The elevation is some 15,000 feet. The vegetation is scanty, while the hillsides are bare and smooth. A peculiar charm pervades the scenery. All is so different from one's accepted ideas of mountain landscape, different from that idea of crags and pine forest-clad ravines that the words "the Alps" instinctively suggest. Here is a vast stretch of open basin and undulating hills, with the distant peaks forming a broken rim to the bowl. It is like some lofty secluded plateau surrounded and guarded by great walls of snow, or it might be some hidden nook deep in the heart of undiscovered lands. The monotonous, featureless hills, the breadth and distance, the absence of life, strike a feeling of awe and sometimes of depression, but yet they attract. One

can feel here the majesty of giant mountains, and at the same time the particular power and fascination of Tibetan scenery, that every traveller in Tibet has felt and described in the same way; an horizon of vast rolling plains, silent, bleak and inhospitable, with ever a cloudless sky above and a wonderful sunshine that sparkles and burns in the thin, crisp, freezing air.

From Zanak, 16,200 feet, to the Choten Nyima La is a long march, and it is best to make a preliminary camp on the shelf below the pass before crossing it. Our camp at this point commanded a superb view to the south of the giant mountains of Kangchenjunga. From here also a part of the Nepalese side of the mountain could be seen. Next morning the camp was astir early as the night had been intensely cold, and also there was a long way to go over unmapped ground on the Tibetan side of the pass. The ascent is tiresome and difficult unless the snow is firm, on account of the slippery loose rock and shingle underfoot. After crossing the pass we scrambled down the rocks on the north side over the névé down to the glacier below. There were some crevasses, but we kept well to the right and avoided them.

The valley, which takes a direction about due north, is barren, desolate and forbidding. A glacier, clinging closely to the western precipitous wall, is itself smooth with no visible crevasses below its névé. It would make a fine ski run if one had skis. At its end, however, the glacier breaks into seracs and terminates in an ice wall at whose foot lies a frozen lake 150 yards broad and 300 yards long. We passed along a shelf high up on the right side of the valley, and after some hours came to the junction of this and the next valley to the east. We now descended to the stream and camped—a long march, but necessarily so, as here was the first firewood to be met. We passed just before this point a stone hut, I expect the identical one mentioned by Sarat Chandra Das as the Tibetan guard-post in the old days of the rigid exclusion of foreigners.

The site of the camp, about 15,600 feet, was particularly desolate, surrounded by bare red gravel and sand slopes, covered in places with the thinnest grass. A few *Ovis ammon* were about. Next morning we set out to discover the position of Choten Nyim, which we had been unable to locate the day before. As it happened we were only three-quarters of a mile away; and we came on the place unexpectedly, as it is hidden beside the banks of a stream which flows between steeply escarped hillsides. Choten Nyim is a collection of cattle enclosures with a temple where three ani (nuns) reside. The temple, dark and gloomy inside, contains a number of idols arranged in rows on shelves round the walls. The place is deemed very sacred; and is visited by Nepalese, Chinese, and pilgrims from Turkestan who travel many hundreds of miles. It is perhaps the weird desolation of these barren plains at the foot of the snows which strikes awe and veneration into the minds of the simple Tibetans.

Here we got the bad news that the yaks had been discovered and stopped at Tonglung, and their advance to the prearranged meeting-place at Tebong had been prevented. We had therefore to set out in a north-easterly direction for Tonglung, which was of course losing ground, since our correct route lay north-west and west.

The country on the north side of the Lhonak mountains is a lofty undulating sandy plain at an elevation of about 15,000 feet, with a slight slope to the north-west. A violent wind sweeps the plain from day to night. On the road about 5 miles from Choten Nyim a magnificent view opened of the lofty snow-peaks of Pherugh, one of the highest being in a bearing 278°. But the Everest group itself is not yet visible because it lies farther south. A high peak was observed at a bearing 322° in distant Central Tibet, 100 or perhaps 150 miles away.

Tonglung village stands on the banks of the stream flowing from the Naku La. Our approach over the satu fields surrounding the village caused much excitement, and the first people we met fled precipitately on seeing us. After an excited discussion in the village, a dwelling was finally prepared for us; and this after further cleaning made a comfortable and warm quarter. The baggage had been seized and locked up, while the yak driver had fled back to Sikkim. Adhu, however, outwitted the Tibetans and got the supplies back. To increase difficulties, the coolies were unwilling to proceed further, with the exception of Tebdoo, a most excellent and stout fellow from Lachen; and they left the next day for Sikkim.

After two days' waiting, the Dzongpen arrived from Kampa Dzong, and an interview was arranged in some yak-hair tents, which had been erected for the purpose outside the village. The Dzongpen was a small man with an effeminate face. He was well dressed in Chinese costume, but wearing a European felt hat. After an exchange of compliments and presents, a discussion ensued lasting about an hour. The Dzongpen was on the whole friendly, and even invited me to visit him at Kampa. He explained as regards the journey to Tashirak that he would facilitate the journey anywhere within his province, but that he could not provide a guide or transport beyond Tebong, which was the boundary of his province. Beyond Tebong the road to Tashirak passes through the province of Tinki.

Some pack-animals having been procured, we started the same day for Mugk. From Tonglung the road crosses the plashy marshes to the hamlet on the far side, and then, bearing to the right along the foot of the hill, enters the broad open Taya Sampo Valley. Proceeding over sandy plains for some hours we passed a low hill, guarded by a fort on its summit, and eventually arrived at Tebong, a ramshackle and deserted place surrounded by the usual walled enclosures. There were ruins of former dwellings. Evidently the place has declined since the days of Sarat Chandra Das's visit.

Tebong is the frontier post of the Shigatse province ruled by the Shigatse Lama. The province is undergoverned by the Dzongpen of Tinki, a small town on the opposite side of the Taya Sampo Valley and visible from Tebong. The Taya Sampo Valley is a remarkable stretch of country 6 to 7 miles broad, but narrowing to the west till beyond Saar the river is said to pass through a defile. The ground is sandy and stony and covered with a low-growing bush which when dried makes excellent firewood. The middle of the valley is marshy.

We changed ponies at Tebong and completed the tiring march over the stony plains to Mugk, a little fort-like village perched on a low hill and surrounded by marshes and barley-fields. Our approach caused intense excitement, and was the signal for barricading the village; not that we wished to enter, for we pitched our tents outside. The pony driver, however, entered the village to stable his ponies, and we learned next day that he and his ponies had been locked up. That evening two horsemen were observed leaving the village and trotting off in the direction of Tinki, evidently to report us. Next day the assistant Dzongpen arrived with his party, the Dzongpen himself being away at the time. This man was very different in his manner from the Dzongpen of Kampa, and he would give neither transport nor supplies. He would only repeat again and again the same old formula: "For what reason have you come to Tibet? You must return immediately by the way you came."

As a result of the interview I saw that it would be impossible to continue the journey under the present conditions of total dependency upon the natives for transport from stage to stage, and against the stubborn resistance of the Dzongpen. I decided therefore to abandon the attempt. I would return to Sikkim, reorganize the caravan, and make a fresh attempt with half a dozen selected men, carrying nothing but a tent and a few blankets and food for as many days as possible. We should then be independent of the officials and natives, and could travel where we wished as long as our rations lasted. After a search through the village Adhu seized four small donkeys, and packing our kit on them, we set off back to Tonglung. From Tonglung by a long and dreary march we retired back to Sikkim by the Naku La into the Lhonak Valley.

Lhonak is a hospitable and delightful land after the bleak plains of Tibet; and at Muguthang on the green swards by the banks of the stream I fixed up a permanent camp, retaining Achum while sending Adhu and Tebdoo back to Lachen to get six men and supplies for a fresh attempt to reach Tashirak. After six days the men came back over the Lugnak Pass from Lachen; and, breaking up the pleasant rest camp at Muguthang, we started again on August 4 for Tibet. Crossing the Choten Nyima Pass once more we arrived at Choten Nyim on the third day. We did not show ourselves this time, but camped in a concealed nullah near by.

From Choten Nyim we made in a north-westerly direction for Mugk,

about 14 miles distant. One cannot strike a direct line, but one is obliged to travel round the arc of a circle bearing always to the left on account of some peculiar sunken watercourses which form an impassable barrier. We encountered one of these, and found ourselves on the edge of a cliff at the bottom of which lay the bed of a glacier stream, dry at this season. We descended to the bottom of the gully by sliding down a conical inclined tunnel about 200 feet long and filled with loose stones, which slid down with us in rather an alarming fashion, raising much dust and noise. In order to avoid these gullies one must go due north almost as far as Tebong before turning west to Mugk.

We camped that night near Mugk at a spot where there was water and firewood. The great difficulty in concealing oneself in these regions is the lack of water and fuel, which obliges one to keep down in the flats of the valley where the villages are situated. Next day we passed Mugk but took no notice of the villagers, who, surprised to see us again, tried to interfere with our advance. We followed the track down the valley, travelling in a westerly direction till we reached the village of Eunah near the mouth of the valley coming down from the Chabuk La. The Taya Sampo valley had here narrowed down considerably. The hillsides had become steeper; and there was some difficulty in locating our position in relation to the Langbu Pass. Two youths, however, who were quite friendly, visited the camp in the evening; and Adhu, by bribing them, obtained some useful information concerning the road to the pass. They said, "Go to Changmu to-morrow—bridge to cross. Go a short way down the river and you will see three chortens. Then, looking up between high stones, go up, and a short way you will find yak paths."

Next day, about 2 miles beyond Eunah we entered a broad, flat valley, flanked by rounded red hills; and, crossing the plain in a diagonal direction, we reached the curious rock-hewn village of Changmu, consisting of about a hundred cave dwellings cut in the face of the cliff. Remembering the boys' directions, which proved quite correct, we crossed a bridge, followed down-stream, and found the chortens and the yak paths among the rocks leading up into the hills.

Continuing to climb we followed good tracks, until, after about 2 miles of ascent, we breasted the spurs and found ourselves looking down into the narrow valley of the Gye River. We were relieved to see a well-marked track winding along the valley, for this showed we were evidently on the right road to the pass. After having marched in all some 11 miles from Eunah we reached a sheep dok, uninhabited, and camped at a height of about 15,000 feet.

A short way above the camp the valley branched, the right branch leading to the Langbu La and the left into the snow mountains to the south and south-west. Next morning, by climbing about 1500 feet up the hillsides, I observed an easy-looking snow col at the head of the valley. It would be interesting to cross this pass, because it would

probably give direct access to the Knagbachen valley in Nepal somewhere near the foot of the great Kangchen glacier. Thus a back door would open to Tibet from Lhonak by the Jongsong Pass, which would be easier than the Chabuk La route described by the natives as being extremely difficult and seldom used. Again, by descending this valley and skirting the foot of the Langbu La direct access could be obtained to Saar village in the Taya Sampo valley. The ascent to the Langbu La is gentle and easy over the barren boulder-strewn ground. In the final climb to the pass, however, the track zigzags steeply 300 feet up a rock wall.

The all-important question was, "Could Everest be seen from the pass?" What were the "lofty Pherugh mountains" that Sarat Chandra Das had described? Were they the Everest group or not? The day was bright and clear, and on breasting the pass a splendid view was revealed. In front towered a magnificent chain of lofty snow-peaks. The centre peak of the range rose a glittering spire of rock, its flanks streaked with snow; and a fine tumbling glacier lay beneath. Behind the sharper and nearer summit rose a higher peak twisted like a hooked tooth, a precipice on the north side and a *névé* on the south. To the left of this again was a long ridged peak, whose winding crest was fantastically corniced—one of the finest specimens of mountain architecture to be seen. The mountains would be about 23,000 feet in height. I have named the peaks, one Taringban (long knife), and the other Guma Raichu (Guma's tooth).*

Presently, while watching the panorama, the shifting of the distant clouds revealed other mountain masses in the background; and directly over the crest of the peak Taringban appeared a glittering spire top of rock fluted with snow, which, according to its magnetic bearing, could be none other than Everest itself. Some 1000 to 1500 feet of the summit was visible.

Although this panorama was in itself a fitting reward for the efforts of the journey, still it was in a sense a disappointment. That wall of mountains was an impassable barrier. Tashirak was near, one had only to descend the valley to reach it; but it was plain that Tashirak offered no open road to Mount Everest. The map upon which the hopes and plans of the journey had been based was incorrect. This mountain range was not shown. The Tashirak River rising in the Langbu La did not flow west into the Arun, but almost due south, while this high mountain range divided the Arun from the Tashirak River.

After remaining an hour on the summit of the pass, during which time the men said copious prayers and built a chorten to which they attached strips of coloured cloth taken from their clothing, we descended into the

* It is to be regretted that the photographs of these mountains were not very successful owing to the high wind blowing over the Langbu pass, which prevented proper exposures being made.

broad desolate valley below. Bearing always to the left we followed the track which brought us to Guma Shara village, where we camped for the night.

Sitting out that evening, admiring the panorama of mountains that dominate Guma from the west, we were visited by two lamas who were friendly and who volunteered some interesting information. The lamas said the only way to reach the Pherugh and Tingri district from Tashirak was by the Nila La and Saar. There was, however, a high-level yak road from Tashirak to the Arun Valley, passing a certain monastery situated on the crest of the dividing range between the two valleys. This monastery was connected with the worship of the mountain "Kangchen-Lembu-Geudyong," of which it commanded an open view. From their account Kangchen-Lembu-Geudyong appears to be the Tibetan name of Mount Everest. They recognized two sacred mountains, Kanchenjunga and Kangchen-Lembu, the former being the more sacred owing to its five heads, while the latter (Everest) has only one head. (The Tibetans would be obviously unaware that Everest was actually the higher peak, owing to the small difference in height, while Kangchenjunga is probably more massive and therefore has the more imposing aspect.) Kangchen-Lembu signifies Kangchen's minister. The mountain is said to contain an interior lake, the word Geudyong being used to signify its crater formation. Pilgrimages are made from Tingri to the neighbourhood of Kangchen-Lembu, where there are a number of shrines dedicated to the worship of the mountain.

The Tibetan pronunciation of Kangchenjunga is Kangchenzeungar.

These details are interesting as regards the native names of Everest, but how far they are correct, or if there are other names, I cannot say because, owing to the hostility to my journey, I was unable to speak with many of the Tibetans whose information could be considered reliable. The Tibetans whom I questioned did not seem to know the name "Makalu," which I believe is a Nepalese name. Makalu, which can be well observed from Indian territory, is known to hold a curious glacier-filled basin on its summit, and so it is quite possible that the Tibetan name I have given may refer to Makalu and not Everest. On this account the information concerning the native names of the mountain should not be accepted as anything more than a report until such time as the complete exploration of Everest is undertaken and this information verified.

From Guma Shara we followed the valley next day to Tashirak. We passed several caravans on the road, mainly Nepalese traders coming from the Kanglachen Pass and proceeding to Saar and Shigatse. There are some small villages in the valley. Tashirak is the frontier guard post, and a fortified wall blocks the valley. The Dalai Lama's rice-tax collector with a guard of soldiers resides there. The officials console themselves with innumerable wives, but besides that there are no other residents.

The Tibetan officials were hostile and wished us to return immediately

THE ROCK-HEWN VILLAGE OF CHANGMU, TIBET

CHOTEN NYIM MONASTERY, TIBET

TASHIRAK, SHOWING FRONTIER WALL. VALLEY ON LEFT LEADS TO KANGLACHEN LA

Taringban. Guma Raichu.

VIEW FROM LANGBU LA LOOKING WEST TOWARDS PEAKS (22-23,000 feet) BETWEEN TASHIRAK AND EVEREST, DISCOVERED AND NAMED BY MAJOR NOEL 1913

the way we had come. We were confronted also with supply difficulties, because our satu and tea had almost given out, and our meat supply had been exhausted some days back. We, however, managed to get a little from the Nepalese caravans who were encamped also at Tashirak and who were quite friendly, and so we were enabled to continue our journey next morning. We struck camp in the early dawn, and, by fording the river, we avoided the bridge and thus passed by Tashirak before the officials had wind of our departure.

Below Tashirak the valley narrows and the scenery becomes alpine with trees and pretty green meadows of moss and luxurious grass. The valley is enclosed by high mountains, and the summits of snow-peaks show themselves high above the mists and clouds. We proceeded as far as the large Nepalese–Tibetan village of Quodo, a short distance beyond which is the Nepalese frontier post and Nepalese guard.

The Tashirak River took a direction almost due south and showed no signs of turning west to join the Arun. A Nepalese, moreover, at Quodo informed us that the Tashirak river joins the Arun at Hatia another two marches down. It was thus useless to proceed further, so we retraced our steps and camped in a side valley about 3 miles below Tashirak. Here we were situated behind the Taringban mountain, and could see the south face of the peak. A ruined fortified wall blocked the valley mouth, and this spot is said to have been the site of a battle in the Tibetan–Nepalese war. It is up this valley that the yak path lay to Pherugh and the monastery, as explained by the lamas of Guma Shara. Therefore it would be interesting to proceed up the valley next day.

An unpleasant surprise, however, came to interfere with our plans, for we had scarcely pitched camp and settled down for the evening when a mounted party of six men rode towards the camp. This was none other than the Tinki Dzongpen himself and his followers. They rode shaggy Tibetan ponies bridled in shining brass and silver-ornamented bridles, and saddled in coloured numdahs. Each pony carried on either side a bulky leather sack and blankets, and, from the general appearance of the party, it was obvious that they had travelled far. We learnt later that the Dzongpen, hearing of our presence, had ridden about 150 miles to meet us, covering the distance in three days.

An interview was arranged which lasted fully two hours and was carried on for some time in rather a heated manner. The Dzongpen, afraid of incurring the displeasure of his superiors lest he should be accused by them of allowing a possible spy (for they mistrust all foreigners) to enter the sacred Lama land, continuously urged that we must return immediately by the road we came. He would listen to no argument and was suspicious of every reason, saying, "No foreigners ever come to Tibet. For what reason do you come?" I complained that I had received only discourtesy and opposition while in Tibet, whereas all Tibetans coming to India were free to travel where they wished, and

were always received as welcome visitors. This was a disgrace to the Tibetan civilization and the Tibetan culture. The whole party became very excited at this juncture, and all started to talk and shout together. The Dzongpen said, "Show me the man who has crossed you?" I answered that it was not any particular man, but that all the villages had been ordered to shun us and refuse us food. At length, after many discussions, I informed the Dzongpen that I would return to India; and finally he and his party took their leave and rode off to Tashirak.

Next morning Adhu came to the tent to say that the Tibetan captain and guard were outside. They said they had been sent to prevent us following the upper road to Pherugh. I went down with my men and, forcing the captain to dismount, we asked him what he meant by posting soldiers on us as if we were common thieves. His soldiers, standing some distance away, were armed with long smooth-bore guns, with rough wooden stocks and folding bipod legs to support the weapon when taking aim. This was the old pattern of arm, totally inaccurate and useless, and very different from the new Lhasa rifles with which the Tibetans fought the Chinese. The soldiers started to crowd round in an insolent manner, but when we made pretence of taking to our arms the captain jumped on his pony, and with him the whole party fled. From a distance behind some rocks they fired two shots. We immediately fired back, aiming over their heads, and finally they cleared the field.

Being discouraged by continuous opposition and having almost come to the end of our food supplies, I decided to discontinue the journey and return to Sikkim. The journey had revealed that there was no open approach to Everest from Tashirak. High snow-peaks and the deep and difficult valley of the Arun intervened and rendered approach from the east very difficult. It would have been interesting to reconnoitre the upper road to Pherugh and visit the reported monastery which was said to command a view of Kangchen-Lembu, but we were at the end of our tether. We had no proper food to eat. The coolies, moreover, on account of their long marches and hardships had been grumbling, and it was only by doubling their pay that I had been able to keep them in hand during the last few days and get them on as far as Tashirak. Accordingly I gave orders to pack up the camp. Slipping by Tashirak without meeting the Tibetans again, we set out for home.

For the return journey we followed the route Langbu Lá, Mugk to Choten Nyim, where we rested two days; thence to Gyabra camping ground, the Naku Pass into Lhonak, and over the Lugnak Pass once more back to the pleasant and comfortable bungalow at Thango in Sikkim on August 24, there to enjoy four days' rest after the fatigues and hardships of travel in Tibet.

In order to profit by the splendid September weather I refitted the caravan, and, taking fresh coolies, set out on August 29 to visit Kangchenjunga and the Zemu glacier, travelling by the Lugnak Pass to Teble

in Lhonak, thence by the The La, 17,400 feet, and Tangchung La, 16,000 feet, to the Zemu glacier, camping at Green Lake at the foot of Kangchenjunga on September 2. That wonderful and gorgeous mountain panorama at the head of Zemu glacier has already been so well described by Mr. Freshfield and Dr. Kellas that no description of mine can add anything. After securing a most fortunate set of photographs of these unique mountains, I returned down the glacier and the forests of the Zemu glen back to Lachen, thence down through Sikkim to Darjeeling and India.

Some day the political difficulties will be overcome, and a fully equipped expedition must explore and map Mount Everest. The journey must be undertaken from the Tingri or northern side, proceeding by Kampa Dzong and the Taya Sampo Valley. While at Saar it would be most profitable to send a detached party by the Nila La to Tashirak to climb the Taringban peak, and so get a direct panorama of the eastern slopes of Everest and Makalu rising from the deep Arun Valley.

Note on the Spelling of Native Names.

In this paper and in the sketch-map the spelling of names is made to conform with the Survey of India. Though I have not made a special study of the pronunciation of Bhutia and Tibetan words, still I have noticed a marked difference between certain names given by the Survey and the native pronunciation of them.

Survey Name.	*Native Pronunciation.*
Kinchinjunga	Kangchenzunga
Kampa Dzong	Kamba Jong
Choten Nyim	Chorten Nyim
Tingri	Dingri
Thango	Tangu
Jongsong	Jonsong
Tista (river)	Teesta

Before the paper the PRESIDENT said: A good many of you, no doubt, like myself, will be very pleased to be back again in the old happy hunting-grounds of the Himalayas. To me it will be a great pleasure to re-visit that historic country, even if it is only for one evening. It is many years since a project was formed for approaching the highest peak of the Himalayas, Mount Everest, with a scientific expedition, and it is six years since the lecturer of this evening, Major Noel, made an adventurous journey over the borders of Tibet in an attempt to reach Mount Everest from the north-east. Apropos of that scientific expedition, which we now hope to see realized, what Major Noel has to tell us ought to be of the very greatest interest. There may be divided views as to which really is the best method of approaching Mount Everest, but we shall hear all that there is to be said about one of them to-night. I will ask Major Noel to begin his address.

Major Noel then read the paper printed above, and a discussion followed.

Mr. DOUGLAS FRESHFIELD: I hoped we might have had an interesting discussion, but the hour, I am afraid, is against it. I may perhaps shorten my

remarks if I put them under heads. First, with regard to Western Himalayan exploration in general. Is it realized that Darjeeling is only a night's journey from Calcutta ; that people go up there for a week-end ; that within that very short distance of what was lately the capital and still is the greatest city in India we have a playground of unrivalled beauty? Yet in order to travel but a few miles north of Darjeeling into "independent Sikkim" a special permit is required. There were good reasons in the past for such restrictions, but there are now stronger reasons for their abolishment. I hope that the district will soon be thrown open to all travellers. But I would ask for something more positive. If a few more horse-roads were made in Sikkim, if, for instance, one was made from Jongri to Pemionchi, visitors to the snows would be able in a fortnight's round tour to approach the great peaks, camp among the native shrines at the base of Kangchenjunga, and return by the Singalela ridge, after having seen what is certainly, as far as I know, the most magnificent scenery in the world. The other path I plead for is one through the few miles of jungle from Lachen to the great Zemu Glacier and the Green Lake Plain. Here and also at Jongri stone huts or bungalows might be built, similar to those erected in the Alps for the shelter of travellers. In that way the Western Himalayas might be made a playground for India. I was personally interested in the very vivid and truthful description that we were given of Lhonak, where the Tista has its sources. The features of this upland district offer a singular contrast to that of the lower valleys and gorges of Sikkim. They exhibit in the most striking fashion the protective power of a cloak of ice as contrasted with the erosive action of water, of rain and torrents. The traveller moves among smooth hillspurs and shallow valleys, in which he can trace the relatively recent retreat of the glaciers by the remains of the moraines they have left behind them. In our days geologists may wonder how de Saussure failed to realize that erratic blocks had been carried not by floods but by glaciers. A hundred years hence physical geographers will, I believe, equally wonder at those among us who allege that glaciers have done more in erosion than in conservation. This is, however, I am well aware, for the moment a controversial forecast.

Next as to climate. I am afraid Major Noel may have led his hearers to believe that the climate of Lhonak is like that of Homer's Islands of the Blest, that it never rains or snows there. I can show you photographs taken by my companion Signor Sella that will prove that it can snow in Lhonak even more heavily than last week in Derbyshire.

With regard to the character of the scenery I venture to differ from Major Noel. I admit that when one comes up from the depressing atmosphere of Sikkim, from the heat and rain of the outer hills into this dry frosty climate, it is like going up to the Engadine from the Lake of Como. One feels so exhilarated that one is ready to admire everything. But so far as my own feelings go I cannot say I thought the Lhonak scenery either really beautiful, or fantastic, or sublime. The bare shallow valleys, the rounded slopes and moderate peaks and glaciers contrast poorly, to my mind, with the forests, the ravines, and the majestic towers, spires, and precipices of the Outer Himalayan range.

With regard to the main subject of the lecture, the eastern approaches to Mount Everest, I think we have got thus much forwarder to-night ; we realize that there are two routes to the mountain, one from the east, and one from the north-east, and that the eastern route, through Tashirak, is the more direct. The best route, however, is doubtless the more northern one from Kampa

VALLEY BELOW TASHIRAK LEADING TO SOUTH SIDE OF PEAK "TARINGBAN," TIBET

THE CHOTEN NYI-MA LA

NORTH-EAST GLACIER FLOWING FROM MOUNT EVEREST

MOUNTAINS NORTH OF MAKALU (27,790) TO SNOUT OF NORTH-EAST MOUNT EVEREST GLACIER

From photographs lent by Dr. A. M. Kellas

Dzong through Tibet, and then south along the track which is known to exist and has been crossed by a pundit, which leads over the western spurs of Mount Everest. A party would not need to cross the frontier of Nepal, and therefore need not get leave from Katmandu. I do not know that there is anything more that I can add in the time allowed me. I must leave Dr. Kellas, who has been far on the same track as Major Noel, to supply any further details with regard to the main subject of the lecture. Dr. Kellas has photographs which I hope he will show, for they seem to represent the view Major Noel describes of two rock peaks with a spire behind. If this is so, the peaks are probably all parts of the Makalu group.

Dr. KELLAS: I have listened with very great interest to Major Noel's account of his adventurous expedition and have admired his magnificent photographs. The problem of the approaches to Mount Everest attracted me when I first visited the Himalayas about twelve years ago, and since then I have studied the matter rather closely, and come to the conclusion that the route described by Major Noel is one of the best from many points of view. The distance from Siliguri to the foot of Mount Everest is probably nearly 300 miles, about 170 miles to Kampa Dzong, and thence about 120 to Mount Everest. The best route is certainly along the Tista Valley, then to Kampa Dzong* and westwards to near the village of Saar, which is on the direct north and south route between Tinki Dzong and Nepal. From Saar this route leads to Tashirak, over the Nila La, a little to the west of the direction taken by Major Noel, who crossed the Langbu Pass. From Tashirak there is a good track to Hatia (or Hatiya) which is just within the Nepalese border, and I believe that boats can be obtained near the village to cross the Arun River. From Hatia the distance to Mount Everest is about 25 miles direct. The route leads northwards up the Arun River, and then to the west. I have been able to get one or two photographs of it not taken by myself. When I first started to study the problem I tried to keep along the side of the dividing range between Nepal and Tibet near the snow-line so as to avoid disturbing the equanimity of the Tibetans or the Nepalese, and a few slides give an idea of the nature of the problem. I tried to go as far as possible along the glacier leading westwards, but the route was not so easy as it at first appeared. There is a great gap a few miles on, the glacier being projected against another with which it has no real connection. The phenomenon is common in photographs of Himalayan scenery and a good example was shown this evening. The peak in Mr. Freshfield's last photograph, which seemed to form the northern part of Mount Everest, is really about 10 miles to the north-east of Everest. These photographs show that the scenery of the Mount Everest group is of a very high order.

There are variations of the route which might be advisable under certain conditions. For example, if one were not allowed to get into Nepal at all, one could not go by Hatia, which is within the Nepalese frontier, and I do not know of any bridge near Tashirak to the west, or any means of getting across the river, which is somewhat difficult at that part. But one could from Kampa Dzong follow a route to the north-west and pass near Tinki Dzong to the north of the Phungtu Chu, which is the name given to the west branch of the Arun River, which rises west of Tingri. The Phungtu Chu is crossed by a hide-rope bridge, and the road then proceeds south along the Arun River to Kharta, whence there are various routes to Mount Everest.

* In discussing routes with the late General Rawling, that *vid* the Tista and Sepo La had been provisionally agreed upon as far as Kampa Dzong.

ASCENDING NORTH OF MAKALU (27,790) TO SNOUT OF NORTH-EAST MOUNT EVEREST GLACIER
From photographs lent by Dr. A. M. Kellas

There is another variation of the route described by Major Noel which might be useful. It is more direct than that *viâ* the Phungtu Chu. One could proceed from Kampa Dzong almost due west to Saar. If one keeps straight to the west from Saar one can cross the mountains, which Major Noel found barred his way, by an easy pass called the Tok-Tok La. Proceeding west from this pass one can reach the village of Kharta previously mentioned on the west side of the river. From Kharta there is a route which leads west for about 10 miles to the Langma La, and that takes one out to the foot of the north-east glacier flowing from Mount Everest. I think that would be the shortest route of the three so far mentioned.

I might add notes of other two routes. There is a route which could be followed from Siliguri or Darjeeling * to the north-west. Instead of going due north along the Tista one could proceed north-west by various routes into the Tambar Valley. At the top of the Tambar Valley there is a good route which was followed by Sir Joseph Hooker in 1849, when he reached the Wallanchoon Pass, a few miles to the south of Tashirak, which is, so far as I can learn, 45 miles in a straight line from Mount Everest, the Wallanchoon Pass being about 50 miles.

There is a third route. One could proceed from Khanwa Ghat on the Kosi River due north along the Arun to Hatia. The direct distance from Khanwa Ghat to Mount Everest is only 110 miles, and the length of this route would be much less than that of the others, approximately 160 to 170 miles in all. It would also be possible, starting from Khanwa Ghat, to attain the south side of Mount Everest: the Hatia route takes one to the north side. About 30 miles north of Khanwa Ghat one can turn to the north-west along the Sun-Kosi River, and then about 40 miles further on, proceed northwards up the Dudh-Kosi River. Part of the eastern headwaters of the latter stream drain the south side of Everest.

Those are the chief routes as far as I have been able to work them out, but there are several other variations of these routes which are of interest, but need not be described.

Captain J. P. FARRAR (President of the Alpine Club): The Alpine Club naturally views with the keenest interest this proposal to attempt the ascent of Mount Everest. Moreover, it seems to me that this attempt now commands chances of success not previously available. The main difficulty hitherto has been transport of equipment and provisions, requiring unmanageable relays of native porters. This has led to great delay, aggravating the unavoidable discomfort and exposure to the European leaders, upon whom the final victory depends, tending to lower their enterprise and powers of work. You have in the modern airship a means of supply which ought to eliminate in a great degree the difficulties that have baulked previous travellers. I think, therefore, that the expedition has every chance of success, and the Alpine Club is prepared not only to lend such financial aid as is in its power, but also to recommend two or three young mountaineers quite capable of dealing with any purely mountaineering difficulties as are likely to be met with on Mount Everest.

Sir FRANCIS YOUNGHUSBAND: It is now twenty-six years ago since our

* I must venture to dissociate myself from Major Noel's remark regarding officials at Darjeeling, as I have invariably found them courteous and obliging. The coolies I have obtained there have always been satisfactory, and some, especially the Sherpa-Nepalese, have been of exceptional merit (cf. *Geog. Journ.*, September 1912, p. 257).

old friend Captain Bruce—now General Bruce—made the proposition to me that we should go up Mount Everest. It did not come to anything then, but years afterwards, in 1903, when I was in Kampa Dzong in Tibet, I had for three months a magnificent view of Mount Everest and Makalu right across the great plain of Tibet. The lecturer hoped that it would be an Englishman, or at any rate a Scotchman, who would first climb Mount Everest. I need only say I think we are all determined that it shall be a British expedition. Our own Society is interested in the project, and we have heard the President of the Alpine Club say he has magnificent young mountaineers ready to undertake it, and it must be done. I dare say there will be one or two attempts before we are successful; and the first thing we shall have to do is to get over the trouble with our own Government. When I went to Tibet in 1903 to 1904 I did get permission for travellers to go to certain places in Tibet. I also got a thing which the Government threw away, and that was the right for an officer to go to Lhasa. Our Government itself has prevented English travellers from going into Tibet and have refused to make use of the privileges which we have obtained. Not only English travellers but others as well have been prevented from going into Tibet. I know French travellers, especially, who wanted to go to a place to which we had a permit for Europeans to go. It is not the Indian Government who are to blame; it is the home Government. But after all, our Government are reasonable if they are approached properly and by societies like this and the Alpine Club. If a reasonable scheme is put before them, and it is proved to them that we mean serious business, then they are reasonable and will do what one wants. But this is a big business, and it must be undertaken in a big way. Most excellent reconnoitring work has been done by our lecturer, Major Noel. We know something of how Mount Everest may be approached from outside Tibet. I suggest that it would be a good thing if, instead of going from the outside, from the Indian side into Tibet, it would be better if we went from inside Tibet itself towards the frontier. I think it better if the head of the expedition made up his mind to go to Gyantse, where we have a permanent official, and get in touch with the big Tibetan officials, and then from the interior proceed towards Mount Everest on the frontier. There are some arguments we can easily put forward. We can point out that the Tibetans are allowed to travel about India as they like, and that this Society itself has a certain claim upon them, because it was Mr. Reeves of this Society who trained a young Tibetan sent over by the Dalai Lama to learn survey work. It would be a graceful act on the part of the Tibetans if they allowed us to make use of their country for climbing Mount Everest.

The lecturer has referred to aeroplane work. I think the Survey of India might be approached to take this up seriously and from the aeroplane get a good photographic survey of the country round Mount Everest. As I say, I am pretty certain that the Government, if they are approached properly by societies such as this, and if a reasonable scheme is put before them, would be quite ready to take it up, so I hope something really serious will come of this meeting. I should like it to be an Englishman who gets to the top of Mount Everest first.

The PRESIDENT: I am afraid it is time to close the discussion. The interesting paper we have heard read contains a great many points for discussion, but unfortunately we cannot continue it now. I have admired more than I can say the wonderful series of photographs which Major Noel has shown us, and I have followed his most adventurous and plucky journey with

the deepest interest. But I venture to think that when any expedition succeeds in reaching Mount Everest it will not be either from the east or north. My own impression is that far the simplest and shortest way is through Nepal. I am quite well aware that if political authorities were asked as to whether it was possible to go through Nepal we should hear at once that it was frankly impossible. I believe myself that this is the way in which finally Mount Everest will be reached.

I have only to ask you now to join in a vote of thanks to Major Noel for his very interesting and attractive lecture, and I hope at some time not very remote we shall be able to hear more about the proposed expedition to Mount Everest.

THE ADMIRALTY TIDE TABLES AND NORTH SEA TIDAL PREDICTIONS

Commander H. D. Warburg, R.N.

Superintendent of Tidal Work, Hydrographic Department, Admiralty.

Read at the Afternoon Meeting of the Society, 17 February 1919.

THE Admiralty Tide Tables were first published for the year 1833, and then contained the times of high water only for the four principal ports in the United Kingdom. By the year 1912 the information had increased to predictions for 54 ports, 26 in the British Islands and 28 in foreign countries and the Colonies: times and heights of both high and low water were predicted at 28 ports, 7 of which were in the British Islands, the times and heights of high water only being given at the remaining 26 ports. The Hydrographic Department does not undertake the calculation of all predictions given in the Admiralty Tide Tables, the present general rule being that predictions for ports in the British Islands and foreign countries are calculated in the Department, those for colonial ports being supplied by the authorities concerned.

The aim of the Tide Tables is to supply, by means of tidal predictions for standard ports and tidal differences for secondary ports on the standard ports, information which will enable seamen to make use of any port in the world independently of information obtained locally.

This aim was far from adequately fulfilled in the tables for 1912, the greater portion of the world being entirely unrepresented in the standard and secondary ports.

Although there had, between the years 1833 and 1912, been a great increase in information, there had been no corresponding increase in accuracy, so far at least as the ports predicted in the Hydrographic Department were concerned, the method of calculation being the same in the latter year as in the former; predictions for colonial ports, however, supplied by the colonial authorities, were in 1912 mostly calculated by the harmonic method. The method used in the Hydrographic Department was that introduced by the late Sir John Lubbock in about the

year 1830 and described in the *Philosophic Transactions* for 1836; in this method as used in the Hydrographic Department tables showing the lunitidal intervals and heights of high and low water for all times of the moon's transit, with the declination and parallax of the moon and sun at their mean values, were calculated from tidal observations obtained at each port to be predicted, these intervals and heights being corrected for the actual declination and parallax of the moon and sun by means of tables calculated in accordance with Bernouilli's theory. The accuracy of these tables of corrections was tested by Sir John Lubbock by means of nineteen years' observations of the time and height of high water obtained at the London Docks, observation and theory being found to be in close agreement.

Predictions by this method fulfilled all requirements at the time of its introduction; the increase in size, speed and draft of vessels however necessitated increased accuracy long before the year 1912. The main defect in Lubbock's method is the entire omission of the diurnal tide; in about the year 1870, therefore, an attempt was made to remedy this by calculating a diurnal correction; very little success was attained. Spasmodic attempts at increased accuracy were continued, but by the year 1912 it had become evident that no real increase in accuracy was possible, and that nothing less than a radical change in method would meet requirements.

The only alternative method then available was the harmonic, which was therefore investigated with a view to its adoption. This method had met with undoubted success at ports in the tropics; there were, however, grave reasons for doubting its accuracy at ports in European waters. It had been tried by the Germans and rejected, the reasons for rejection being, as stated in their published Tide Tables, "the serious discrepancies which exist between predictions and observations"; and predictions for ports in the United Kingdom, calculated by this method, published in the Tide Tables of the United States Coast and Geodetic Survey, were even less accurate than those by Lubbock's method in the Admiralty Tide Tables. The U.S. predictions were, however, mostly calculated from insufficient observations, and but little importance could be attached to their lack of accuracy; the deliberate German statement, on the other hand, appeared to be of great importance.

Extended investigation, whilst proving that a very high degree of accuracy was reached at ports out of Europe, brought to light certain minor but irremediable defects, only one of which need be mentioned. To the seaman the most important part of tidal predictions is the time of high water; for actual depth of water at any place at any moment accurate knowledge of the times and heights of both high and low water is essential; but as, in Admiralty publications, the turn of the tidal stream is always referred to the time of high water, this time is doubly important. It was almost invariably found that, in harmonic predictions, the heights reached

a considerably higher degree of accuracy than the times, the probable reason being that, as the times depend on the amplitudes of the component waves, small errors in these amplitudes, due possibly to the short length of the series of observations usually analyzed, cause considerable errors in the actual moment of high or low water without appreciably affecting the heights.

A point which has since been noticed, but which may be mentioned here, is the fact that harmonic predictions obtained by different authorities by means of different machines, but using the same set of constants, may differ materially. The predictions for London and for Panama, published in the Tide Tables of the United States Coast and Geodetic Survey and in the Admiralty Tide Tables, are calculated from the same sets of constants, yet differences in time of as much as fifteen minutes exist, showing that harmonic predictions are affected by either personal or instrumental errors, or both.

The decision reached at the conclusion of the investigation was to make a commencement with harmonic predictions, but at the same time to attempt to evolve a new method which, whilst retaining the advantage, the separate and independent prediction of times and heights, of Lubbock's method, would give the desired degree of accuracy. In consequence of this decision Mr. Edward Roberts was employed to calculate harmonic predictions for certain ports, investigation of a new method being continued in the Hydrographic Department.

Predictions for Dover, London, Immingham, Stromness, Oban, Liverpool, and Avonmouth, calculated by the harmonic method, are now included in the Admiralty Tide Tables, and these predictions reach a high degree of accuracy. Success has also been attained in the investigation of a new method of prediction, and predictions for 19 ports, 15 in the British Islands, 3 in Germany, and 1 in the Netherlands, based on this method, which has been called the Equation method, will be included in the Tide Tables for 1920 now in course of preparation. In the tables for 1919 predictions for 18 ports depend on this method.

In addition to the increase in accuracy, due to the change in methods of prediction, there has been a considerable increase in the quantity of information given between the Tide Tables for 1912 and those for 1920. The tables for 1912 included, as mentioned above, predicted times and heights of high and low waters at 28 standard ports and times and heights of high water at 26 standard ports. Differences in time and height of high water on standard ports for some 220 secondary ports were also given. The tables for 1920 will include predicted times and heights of high and low water at 62 standard ports, and differences, in most cases of time and height of both high and low water, on standard ports, for some 2000 secondary ports.

Though improvements of considerable magnitude have thus been made in the Tide Tables, much work yet remains, neither standard nor secondary

ports in the United States or in the greater part of South America, Africa, and Eastern Asia being given. Work has been delayed by war requirements, also by investigation of methods of prediction; but as war requirements are reaching their end, and as investigations are for the time being completed, improvements should now proceed with increasing rapidity.

Before describing the equation method of tidal predictions, some information as to the degree of accuracy attained in the prediction of the tides at ports in the British Islands may be of interest. The proper judging of the accuracy of tidal predictions is not a simple matter. The tides are affected by meteorological conditions, and, unless corrections for these conditions are applied, there is no means of telling whether differences between predictions and observations are due to errors in prediction or to meteorological causes. Tables of corrections for meteorological conditions have not been calculated for any port in the British Islands; as the predictions include tidal changes due to seasonal variations in wind, rainfall, and barometric height, the calculation of such tables involves the comparison of a very considerable series of observations and predictions, separate tables being required for each month, or, at any rate, for each season. No time has been available for this work.

Tidal predictions calculated from the short series of observations usually employed are not exact; to obtain, therefore, a true measure of the relative accuracy of different methods, predictions by each method should be calculated for the same port from the same series of observations, and the same days' predictions should be compared in each case. This again requires much time, which has not been available

There is no standard method of ascertaining the accuracy of predictions; the method usually employed is to count all predictions which differ from observations by not more than ten minutes in time or 1/10 of the range of the tide in height as correct: all others as incorrect. This method is not satisfactory, for predictions correct within 5 minutes are of more value than those within 10 minutes, and so long as the error does not exceed 15 minutes the predictions are of some value. The height allowance of 1/10 of the range is also unsatisfactory; this may, at St. Helier or Avonmouth, for instance, exceed 4 feet, and a predicted height 4 feet in error is of no value anywhere.

The following method of comparison is now used in the Hydrographic Department: summer tides only are compared, thus eliminating, as far as possible, meteorological disturbances; a maximum of 3 marks is given for each predicted time which differs by not more than 5 minutes from the observed time, and for each height which differs by not more than 0·5 foot from the observed height; 2 marks are given for times which differ by more than 5, but not more than 10 minutes, from the observed time, and for heights which differ by more than 0·5 foot and not more than 1 foot from the observed height; where differences are greater than 10 minutes or 1 foot, but not more than 15 minutes or 1·5 feet, 1 mark is given; for

differences of more than 15 minutes or 1·5 feet no marks are given. The total obtained is then finally given in the form of a percentage of the possible total.

For the comparison of the relative accuracy of the harmonic and equation methods the following ports have been chosen:

1. Liverpool, predicted by the harmonic method from eight years' observations, 1857–1860, 1867–1870, and 1902.
2. Immingham, predicted by the harmonic method from one year's observations, 1912.
3. River Tees entrance, predicted by the equation method from one year's observations, 1897.
4. River Tyne entrance, predicted by the equation method from one year's observations, 1915–16.

The comparisons in each case covered three months, May to July 1918, except at Immingham, where comparisons were made for May to July 1917.

Results are given for comparisons both by the Hydrographic Department method and by that usually employed, and are:

Liverpool.	90 per cent. correct within 10 minutes or 1/10 range.
	81·5 per cent. by Hydrographic Department method.
Immingham.	91 per cent. correct within 10 minutes or 1/10 range.
	82·8 per cent. by Hydrographic Department method.
River Tees.	95 per cent. correct within 10 minutes or 1/10 range.
	84·4 per cent. by Hydrographic Department method.
River Tyne.	98 per cent. correct within 10 minutes or 1/10 range.
	90·4 per cent. by Hydrographic Department method.

A high degree of accuracy is thus reached in all cases, results by the equation method being slightly the better; it must, however, be admitted that the equation method decreases in accuracy as the diurnal tide increases and cannot be used at all at places where single day tides occur, and is therefore valueless in many parts of the world. It should perhaps also be stated that, in the comparisons given, the predicted tides for Liverpool were compared with the times and heights of high and low water as supplied by the Mersey Docks and Harbour Board; those for Immingham, the River Tees, and the River Tyne were compared with the original automatic tide-gauge records.

The equation method of prediction has been of considerable value during the past four years. Prior to 1914, in the course of the ordinary exchange of Hydrographic information, tidal predictions were exchanged with the German Hydrographic Department, predictions for German ports included in the Admiralty Tide Tables being supplied by the German Hydrographer in exchange for predictions for British ports included in the German tables. In 1914 this source of supply ceased but accurate predictions for German ports were of almost vital importance. The ports which it was desired to predict were Wilhelmshaven, Cuxhaven, and Heligoland, the material available being:

Wilhelmshaven: Harmonic constants obtained from German publications; these were, in all probability, the constants at one time used for the German predictions which were said to be unsatisfactory.

Cuxhaven: Incomplete observations of the times and heights of high and low water for the years 1841, 1842, and 1843.

Heligoland: Incomplete hourly ordinates for the year 1880, obtained from the records of an automatic gauge which the German Government had been allowed to establish while the island was still in British occupation, together with a few observations obtained by Admiralty surveyors in the summer of 1855.

These could hardly be regarded as satisfactory data on which to base important predictions, but inquiry led to the obtaining, in addition, of harmonic constants for Heligoland, calculated by the U.S. Coast and Geodetic Survey, derived from four complete years' hourly ordinates, 1882, 1883, 1894, and 1895.

As the only available information for Wilhelmshaven and Heligoland consisted of harmonic constants, it was decided to use the harmonic method for predicting the tides at all three ports, and Mr. Roberts was convinced of his ability to produce accurate predictions from the material available. The predictions, when calculated, were found to differ very materially from those calculated in Germany for the use of the German fleet; time differences of an hour or more were found at all ports; and the height differences were also very considerable, the differences both in time and in height exhibiting great similarity in all cases. As a check on accuracy, harmonic predictions for Heligoland for the summer of 1855 were then calculated and compared with the Admiralty surveyors' observations of that year. Differences were again large and similar to those existing between the harmonic and German predictions.

The exact method by which the German predictions are calculated is not known, but it is known that it is not harmonic and that the only port for which direct predictions are calculated is Wilhelmshaven, where they depend on seven years' observations, 1903–1909, predictions for other ports being calculated from the Wilhelmshaven predictions by means of variable differences obtained from several years' observations; as observations were not available, except for Cuxhaven, it was decided to calculate predictions for Wilhelmshaven by the equation method, using the German predictions as basis, and to calculate Cuxhaven and Heligoland by means of variable differences on Wilhelmshaven obtained from the German predictions.

Assuming the German predictions to be accurate, complete success was obtained, the Admiralty figures agreeing almost exactly with those calculated in Germany; but as a final test predictions for Heligoland were calculated for the summer of 1855, for comparing with the Admiralty surveyors' observations. Results showed a considerable improvement on the harmonic predictions, but the expected degree of accuracy was not

attained. By the Admiralty method of marking, the accuracy of the harmonic and equation methods of prediction, respectively, from comparison with the 1855 observations was—harmonic 59·7 per cent., equation 70·4 per cent. By the same method of marking, comparing with the German predictions for Heligoland, accuracy was—harmonic 62·1 per cent., equation 96·8 per cent.

It is evident from these figures that the German predictions and the 1855 observations are not in exact agreement, but, as the observations on which the predictions depend were obtained at the south end of the island whereas the 1855 tidal station was near the north point, very little importance can be attached to the differences which exist; the German predictions are, in fact, known to reach a reasonable degree of accuracy.

Differences between the German and harmonic predictions have been partially analyzed, and it has been found that, though there are errors of other periods which cannot be easily placed, the principal error in the time of high water has a period of half a synodic month, and is therefore in the phase inequality. This error varies with approximate regularity from about zero to about +40 minutes, and the predicted times of high water could be materially improved by applying a periodical correction of this nature; but as the corrections required to the times of high and low water differ, and the heights require separate corrections, and as the predictions after correction do not attain the accuracy of those by the equation method, harmonic predictions for German ports have been discontinued.

Tidal predictions for the Admiralty Tide Tables are prepared some years in advance, and those for German ports in the Tables for 1916, 1917 and 1918 were calculated by the harmonic method; special predictions for those years were issued to H.M.'s ships and it was not considered necessary to correct those published in the Tide Tables, but the German Admiralty have considered that correction should be made, the following being a translation of a portion of Berlin Notice to Mariners, No. 1319/18:

"English Tide Tables.—When using English Tide Tables it should be noted that the predictions for Wilhelmshaven are calculated by means of harmonic constants. The use of harmonic constants for Wilhelmshaven gives values which are inadmissible owing to their inaccuracy. The errors amount to as much as 45 minutes."

Harmonic predictions for German ports can thus not be regarded otherwise than as a failure; the ascertaining of the true reason for failure is a matter of considerable importance, for unexpected failure in one case is liable to lead to doubts as to accuracy in other cases. The great majority of the ports hitherto predicted by the harmonic method have deep-water approaches, very few being situated on rivers or shallow estuaries. Exceptions to this are the ports on the River Hugli included in the Tide Tables published by the Government of India, Liverpool, Avonmouth, Immingham, and possibly also some United States ports. The predictions for the Indian Tide Tables are calculated at the National

Physical Laboratory, Teddington, those for the English ports by Mr. Roberts; and in both cases non-harmonic corrections to the low-water predictions have been found necessary. Mr. Roberts, I believe, applies such corrections at Avonmouth only, though the Liverpool predictions would probably be improved by their use, for at this port the errors are considerably greater in the low than in the high water predictions. Partial failure of harmonic predictions, owing, in all probability, to the extreme alteration in the shape of the tide wave due to shallow water and other local circumstances, is thus not entirely unknown.

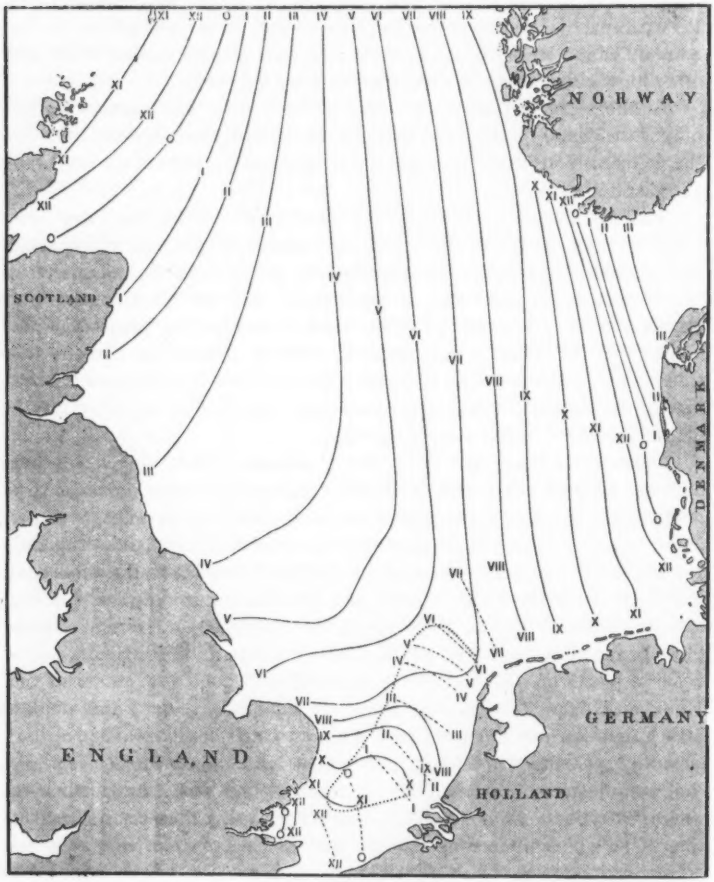
At the German ports tidal conditions are even more involved; not only is the shape of the wave changed by shallow water, but the tides on the German North Sea coast are due to the combination of two separate and distinct waves.

The co-tidal lines shown on the chart of the North Sea have been taken from an Admiralty chart, and are founded on observations obtained by Admiralty surveyors; the observations are incomplete, especially in the northern portions, and a considerable amount of filling in was required in compiling the chart; the main features of the progress of the North Sea tide waves were, however, distinctly shown by the observations. The advance of the northern wave is shown by continuous lines, that of the southern wave by pecked lines; the Roman figures give the lunitidal interval on full and change days.

As the chart shows, the North Sea is affected by two tide waves, one entering through the Straits of Dover, causing high water on the coasts of Belgium and the Netherlands, the other entering between Scotland and Norway, causing high water on the coasts of Scotland, England, Norway, and Denmark. Between the coasts of Norfolk and Suffolk and the Netherlands these waves meet, and an area accordingly exists in this locality in which double tides occur, the approximate limit of double tides being within the area surrounded by a dotted line. Double tides occur at places on the coast of the Netherlands, double low waters at the Hook of Holland and double high waters at the Helder; and double high waters are not unknown in the entrance to the River Thames, but generally speaking the double tides do not reach the shore. Near the centre of the area of double tides the times of high water due to the two waves are about six hours apart, and consequently there is no regular tide at all; it is interesting to note that the existence of this area was originally suspected by Whewell, and confirmed by observations by Captain Hewitt, R.N., in the year 1840. Unfortunately the original observations, which were obtained by measuring the depth of water at a moored boat, though undoubtedly still in existence, cannot at present be found, and exact particulars can therefore not be given. The region of no tide was placed by Captain Hewitt some distance to the northward of that resulting from modern observations, but as the observations now available are insufficient for settling exactly the boundaries either

of the region of no tides or that of double tides, no importance can be attached to this discrepancy. It is even possible, in fact probable, that the boundaries are not fixed and differ at different periods of a lunation and at different seasons.

Off the north coast of the Netherlands, on a line situated in about



Co-tidal lines in the North Sea

6° E. and running nearly north and south, the waves combine, and the tides of the bay formed by the coasts of Germany and Slesvig are due to the combined wave.

That the ratio between the solar and the lunar tides varies in different regions is a well-known fact; the variations are probably greater in the

North Sea than in any other area of similar size. At Ostende, in the southern tide wave, the ratio of the solar to the lunar wave is 1 : 4·6; at Thurso, in the northern wave, the ratio is 1 : 2·5. Assuming that these ratios for the southern and northern waves remain constant, and that the lunar components of the waves are of equal magnitude, then, at springs the ratio, in the combined wave, of northern to southern would be 1·2 : 1, the corresponding ratio at neaps being 0·8 : 1, the combined wave being thus predominantly northern at springs and southern at neaps. It is probable that this change in composition of the wave accounts for that part of the difference between harmonic prediction and observation at German ports which has a period of semi-lunation, and the error could possibly be eliminated by the inclusion of a special constant. This would, however, though increasing accuracy, not be sufficient, and, if the theory of different composition of the wave at springs and at neaps is correct, additional special constants would be required for each of the more important harmonic constants.

Though this theory may be correct as to the spring and neap variation it is not correct as to amount, for, if the ratios given for the northern and southern waves were correct, the resulting average ratio on the German coast of the solar to the lunar tide would be about 1 : 3·5, whereas it is at Heligoland 1 : 5·5 and at Wilhelmshaven 1 : 7·8. These values have been calculated from the phase inequality of height; at Wilhelmshaven the ratio of the solar to the lunar tide, as calculated from the phase inequality of time, is 1 : 2·7 only.

In the harmonic method of tidal prediction the analysis includes the whole tide wave; in the equation, as in Lubbock's, method only the lunitidal intervals and heights of high and low water are dealt with, and prediction consists in the application to the mean lunitidal intervals and heights of corrections for phase inequality, and for changes in the parallax and declination of the moon and sun.

Lubbock's method depends on Bernouilli's theory, and therefore, at any rate when first introduced, assumed a constant ratio between solar tides, lunar tides, and changes due to changes in declination and parallax; the corrections made to the lunitidal intervals for phase-inequality, parallax, and declination were therefore the same at all places, but the corresponding height corrections varied with the mean range of the tide. Corrections calculated by theory were tested by means of corresponding corrections calculated from nineteen years' observed times and heights of high water at London; the phase correction was found to differ materially in observation and theory; the parallax and declination corrections were, on the other hand, in close agreement. In predictions by this method, therefore, the mean lunitidal intervals and heights and the phase inequality corrections were obtained from observations at each port predicted; the parallax and declination corrections, on the other hand, were calculated by theory, and were the same for all ports.

It is unfortunately a fact that the London corrections, as calculated by Sir John Lubbock, agree very closely with Bernouilli's theory, and that diurnal inequality is practically non-existent in the London high-waters, for these facts led to the assumption that the tides at all ports could be predicted by this method, and that the omission of the diurnal tide was of no importance. This method was therefore used for predicting tides not only in the British Islands, but also at Georgetown, British Guiana, and, though predictions were never printed, at Hong Kong.

Shortly after the publication of Lubbock's tables in the *Philosophical Transactions* for 1836, Whewell calculated corresponding tables from tidal observations at Devonport. These tables differed materially from Lubbock's, but, though they were used for predicting the Devonport tides, it appears to have been assumed either that these tides were exceptional, or that, as the time corrections were calculated from only three, and the height corrections from only five, years' observations, the tables were inaccurate. Whewell also calculated a simple table of diurnal corrections to the heights at Devonport. The publication of these Devonport tables appears to have caused some uneasiness in the Hydrographic Department, for the calculation of corrections from seven years' observations at Leith was commenced; this work was never completed, and Lubbock's tables continued in use for all ports in the United Kingdom predicted in the Admiralty Tide Tables, with the exception of Devonport.

That all was not well was known, and from time to time attempts at correction were made. The only attempts, however, which reached any practical results were the calculation, by Captain W. N. Goalen, R.N., on a method of his own, of tables for predicting the Harwich tides, and of a table of diurnal corrections to the heights at Portsmouth. Both of these were adopted, and added materially to the accuracy of the predictions for these ports.

In Lubbock's method it is assumed that the ages of the phase, declinational, and anomalistic inequalities are the same. This is not correct, and, though alterations in method could no doubt be made, and accurate tables of all necessary corrections calculated, the period of observations required would, owing to the necessity for calculating corrections for both increasing and decreasing declination and parallax, be long, probably at least ten years. There are not many ports for which so long a series of observations is available, and were all necessary observations obtained, the labour of dealing with them would be enormous; it was therefore decided to attempt the calculation of corrections from a comparatively short series of observations and by a new method.

The tide wave, and changes or inequalities, to be considered in a method of prediction where times and heights are separately considered, are:

(*a*) The mean lunar semidiurnal wave.

(*b*) The phase-inequality, or effect of the mean solar semidiurnal wave on the mean lunar semidiurnal wave. Period, half a synodic month.

(*c*) The lunar tropical diurnal inequality, or diurnal effect on the phase-inequality of the changes in the moon's declination. Period, one tropical month.

(*d*) The lunar tropical semidiurnal inequality, or semidiurnal effect on the phase-inequality of changes in the moon's declination. Period, half a tropical month.

(*e*) The lunar anomalistic semidiurnal inequality, or effect on the phase-inequality of changes in the moon's parallax. Period, one anomalistic month.

(*f*) The solar tropical diurnal inequality, or diurnal effect on the phase-inequality of changes in the sun's declination. Period, one solar year.

(*g*) The solar tropical semidiurnal inequality, or semidiurnal effect on the phase-inequality of changes in the sun's declination. Period, half a solar year.

(*h*) The solar anomalistic semidiurnal inequality, or effect on the phase-inequality of changes in the sun's parallax. Period, one solar year.

(*k*) The annual variation in height, due in all probability to seasonal meteorological changes. Period, one solar year.

The mean lunar tide and phase-inequality are easily found, by a system of means, from a series of tidal observations extending over a year or more; if the mean tide for any time of moon's transit be deducted from an observed tide of the same series and time of transit, the remainder will be the "total correction" or sum of inequalities (*c*) to (*k*) for the time of moon's transit, date, parallax, and declination of the moon and sun.

The solar inequalities (*f*) to (*h*) are known to be small, and the finding of each separately complicates the analysis; all but (*g*) have a period of a solar year, and, as this is also the period of (*k*), their inclusion with (*k*) in a single solar inequality will involve but little error and will simplify calculations. This inequality will vary with the date.

The attempt to divide the total correction into inequalities is also complicated by the fact that it contains an unknown correction due to temporary meteorological conditions, and by the minutes in the time of moon's transit and the change in the moon's parallax and declination in the interval between the upper and lower transits. In order, as far as possible, to overcome these difficulties, the whole series of observations, which should extend over fourteen synodic months, is plotted on section paper, the diagram showing date; time of moon's transit, upper in black, lower in red; lunitidal intervals and heights of high and low water, tides following upper transit in black, lower transit in red; moon's declination,

north in black, south in red; and moon's parallax. Mean curves of intervals and heights following the upper and lower transits of the moon are then drawn through the points plotted, thus eliminating to some extent the effect of temporary meteorological disturbances, and from these curves the intervals and heights corresponding to exact hours of moon's transit may be obtained, the tides following the upper and lower transits appearing simultaneous.

From the diagram twelve tables are compiled, for moon's transits 0^h or 12^h, 1^h or 13^h, 2^h or 14^h . . . 11^h or 23^h, each table giving date, time of moon's transit, moon's declination and parallax, and the lunitidal intervals and heights of high and low water. In the tables the colours of the diagram are followed, and the moon's declination and parallax are further distinguished as "increasing" and "decreasing."

The colours black and red are used in order that the lunar tides may be separated into "like" and "unlike." Like tides occur after moon's upper transit with north declination (both black) and lower transit with south declination (both red); unlike tides occur after moon's upper transit with south declination (black and red), or lower transit with north declination (red and black). The colours of transit and declination thus distinguish tides into like and unlike; the colours of the tides, however, distinguish those following the moon's upper transit (black) from those following the lower transit (red).

Each table consists of twenty-eight dates, half a synodic month apart, with one lunar declination and parallax, two transits, and two tides for each date.

The high and low water lunitidal intervals and heights in each table are now meaned, red and black separately, the mean giving, for each table, a value for mean lunar tide ± phase-inequality for the tides following the upper and lower transits, the difference between each mean and the quantities meaned giving total correction according to time of transit, upper or lower, date, declination and parallax, like or unlike tide.

On any date a, time of moon's upper transit T^h, lower transit $T + 12^h$, declination Δ° increasing, parallax (measured from the mean parallax) P′ increasing: if x and x' are the total corrections to tides following upper and lower transit, D and d the diurnal and semidiurnal corrections for moon's declination, p the correction for moon's parallax, s the solar correction,

(1) $x = (d + \mathrm{D}) + p + s$ (Like tides).
(2) $x' = (d - \mathrm{D}) + p + s$ (Unlike tides).

At the next date, half a synodic month from a, assuming the synodic, tropical, and anomalistic months to be of equal length and each to be a very small proportion of a solar year, the moon's declination will be $-\Delta^\circ$ increasing and parallax $-\mathrm{P}'$ increasing, and if x'' and x''' are the total corrections following the moon's upper and lower transits,

(3) $x'' = (d - D) - p + s$ (Unlike tides).
(4) $x''' = (d + D) - p + s$ (Like tides).

After the lapse of $6\frac{1}{2}$ synodic months from α the moon's declination and parallax will be nearly as at α, and if X and X′ are the total corrections following the moon's upper and lower transits, assuming that $6\frac{1}{2}$ synodic = 6 solar months,

(5) $X = (d + D) + p - s$ (Like tides).
(6) $X' = (d - D) + p - s$ (Unlike tides).

Seven synodic months from α, X″ and X‴ being the total corrections following the moon's upper and lower transits,

(7) $X'' = (d - D) - p - s$ (Unlike tides).
(8) $X''' = (d + D) - p - s$ (Unlike tides).

From these eight equations, on which the equation method of predicting tides depend, and at date α and $\alpha + 6\frac{1}{2}$ synodic months,

$$p = \tfrac{1}{16}\{(x - x''') + (x' - x'') + (X - X''') + (X' - X'')\}$$
$$(d + D) = \tfrac{1}{4}\{(x + x''') + (X + X''')\},\ (d - D) = \tfrac{1}{4}\{(x' + x'') + (X' + X'')\}$$
$$s = \tfrac{1}{8}\{(x + x''') - (X + X''') + (x' + x'') - (X' + X'')\}$$

As the synodic, tropical and anomalistic months are not exactly equal, the corrections for each date should be calculated for half a synodic month back as well as half a synodic month on; the corrections $(d + D)$ and $(d - D)$ accepted as corrections for the mean declination at dates α and $\alpha + 6\frac{1}{2}$ synodic months, p should be accepted as the correction

TABLE I.

As obtained from Diagram.

(All Intervals +2 days.)

Date.	Moon's			High water.				Low water.			
	Transit.	Dec.	H.P.	Interval.	Corr.	Height.	Corr.	Intetval.	Corr.	Height.	Corr.
	H. M.	°	′	H. M.	M.	F.	F.	H. M.	M.	F.	F.
16 Sept. 1915	18 00	*27*	59·2 d.	5 18	+ 7	10·6	− 0·7	12 04	+ 27	2·0	− 2·0
	6 00			*5 35*	+ 20	*10·7*	− 0·5	*11 55*	+ 17	*3·2*	− 0·9
1 Oct.	6 00	26 d.	54·5 i.	5 30	+ 19	9·1	− 2·2	11 58	+ 21	4·6	+ 0·6
	18 00			*5 15*	0	*9·6*	− 1·6	*12 07*	+ 29	*3·7*	− 0·4
16 Oct.	18 00	*24* d.	58·8 d.	5 07	− 4	10·7	− 0·6	11 58	+ 21	1·9	− 2·1
	6 00			*5 33*	+ 18	*10·7*	− 0·5	*11 52*	+ 14	*3·8*	− 0·3
25 Mar. 1916	6 00	*26* d.	59·2 i.	4 50	− 21	12·5	+ 1·2	11 30	− 7	3·9	− 0·1
	18 00			*5 10*	− 5	*12·2*	+ 1·0	*11 40*	+ 2	*5·5*	+ 1·4
10 April	18 00	24 d.	54·2 i.	5 34	+ 23	11·1	− 0·2	11 44	+ 7	6·0	+ 2·0
	6 00			*5 20*	+ 5	*11·1*	− 0·1	*11 41*	+ 3	*4·9*	+ 0·8
24 April	6 00	*21* d.	59·2 d.	5 00	− 11	11·7	+ 0·4	11 41	+ 4	2·0	− 2·0
	18 00			*5 33*	+ 18	*11·3*	+ 0·1	*11 38*	0	*3·9*	− 0·2
Means (as derived from complete table)				5 11		11·3		11 37		4·0	
				5 15		*11·2*		*11 38*		*4·1*	

Note: figures printed in italics are to be considered RED.

for the mean parallax at α and $\alpha + 6\frac{1}{2}$ synodic months, s as the solar correction at α, and at $\alpha + 6\frac{1}{2}$ synodic months.

As an example the tides necessary for calculating the corrections for one lunar declination, one parallax and two dates have been taken from the tidal diagram by means of which the tables for predicting tides at the River Tyne entrance were calculated and the corrections worked out.

TABLE II.

Total corrections.

Date.	Moon's			Like tides.				Moon's transit.	Unlike tides.			
				High water.		Low water.			Low water.		Low water.	
	Transit.	Dec.	H.P.	Int.	Height.	Int.	Height.		Int.	Height.	Int.	Ht,
	H.	°	′	M.	F.	M.	F.	H.	M.	F.	M.	F.
16 Sept. 1915	6	27	59·2 d.	+ 20	− 0·5	+ 17	− 0·9	18	+ 7	− 0·7	+ 27	−2·0
1 Oct. ,,	6	26 d.	54·5 i.	+ 19	− 2·2	+ 21	+ 0·6	18	0	− 1·6	+ 29	−0·4
16 Oct. ,,	6	24 d.	58·8 d.	+ 18	− 0·5	+ 14	− 0·3	18	− 4	− 0·6	+ 21	−2·1
25 Mar. 1916	18	26 d.	59·2 i.	− 5	+ 1·0	+ 2	+ 1·4	6	− 21	+ 1·2	− 7	−0·1
10 April ,,	18	24 d.	54·2 i.	+ 23	− 0·2	+ 7	+ 2·0	6	+ 5	− 0·1	+ 3	+0·8
24 April ,,	18	21 d.	59·2 d.	+ 18	+ 0·1	0	− 0·2	6	− 11	+ 0·4	+ 4	−2·0

TABLE III.

Half sum of lines from Table II.

Date.	Moon's		Like tides.				Moon's transit.	Unlike tides.			
			High water.		Low water.			High water.		Low water.	
	Transit.	Dec.	Int.	Height.	Int.	Height.		Int.	Height.	Int.	Height.
	H.	°	M.	F.	M.	F.	H.	M.	F.	M.	F.
1 Oct. 1915	6	26 d.	+ 19·5	− 1·35	+ 19·0	− 0·15	18	+ 3·5	− 1·15	+28·0	− 1·20
1 Oct. 1915	6	26 d.	+ 18·5	− 1·35	+ 17·5	+ 0·15	18	− 2·0	− 1·10	+25·0	− 1·25
10 April 1916	18	24 d.	+ 9·0	+ 0·40	+ 4·5	+ 1·70	6	− 8·0	+0·55	− 2·0	+0·35
10 April 1916	18	24 d.	+ 20·5	− 0·05	+ 3·5	+ 0·90	6	− 3·0	+0·15	+ 3·5	− 0·60
1 Oct. 1915	6	26 d.	+ 19·0	− 1·35	+ 18·2	0·00	18	+ 0·7	− 1·12	+26·5	− 1·22
10 April 1916	18	24 d.	+ 14·7	+ 0·17	+ 4·0	+ 1·30	6	− 5·5	+0·35	+ 0·7	− 0·12

TABLE IV.

Correction for Moon's Declination.

(Half sum of last lines of Table III.)

Moon's Dec.	Like tides.				Unlike tides.			
	High water.		Low water.		High water.		Low water.	
	Int.	Height.	Int.	Height.	Int.	Height.	Int.	Height.
°	M.	F.	M.	F.	M.	F.	M.	F.
25 d.	+ 16·8	− 0·59	+ 11·1	+ 0·65	− 2·4	− 0·38	+ 13·6	− 0·67

TABLE V.

Solar Correction.

(Half difference of last lines of Table III.)

Date.	Mean tides.			
	High water.		Low water.	
	Int.	Height.	Int.	Height.
	M.	F.	M.	F.
1 October	+ 2·1	− 0·76	+ 7·1	− 0·65
1 October	+ 3·1	− 0·73	+ 12·9	− 0·55
10 April	− 2·6	+ 0·75	− 10·0	+ 0·60
1 October	+ 2·6	− 0·75	+ 10·0	+ 0·60

TABLE VI.

Correction for Moon's Parallax.

(Half difference of lines from Table II.)

Moon's H.P.	Mean tides.			
	High water.		Low water.	
	Int.	Height.	Int.	Height.
′	M.	F.	M.	F.
54·5 i.	− 0·5	− 0·85	+ 2·0	+ 0·75
54·5 i.	− 3·5	− 0·45	+ 1·0	+ 0·80
54·5 i.	+ 0·5	− 0·85	+ 3·5	+ 0·45
54·5 i.	+ 2·0	− 0·50	+ 4·0	+ 0·85
54·2 i.	+ 14·0	− 0·60	+ 2·5	+ 0·30
54·2 i.	+ 13·0	− 0·65	+ 5·0	+ 0·45
54·2 i.	+ 2·5	− 0·15	+ 3·5	+ 1·10
54·2 i.	+ 8·0	− 0·25	− 0·5	+ 1·40
54·35 i.	+ 4·5	− 0·54	+ 2·6	+ 0·76

From the complete diagram and 12 complete tables, 12 values are obtained for lunar tide ± phase-inequality for the tide following the moon's upper transit, 12 values for the tide following the lower transit; values for $(d + D)$ and $(d - D)$ for 13 declinations, values of p for 13 parallaxes and values of s for 26 dates in each of the 12 tables. These values are plotted on squared paper and curves drawn, the complete tables of corrections compiled from the curves giving

I. Mean lunar tide ± phase-inequality for all times of moon's upper and lower transits.

II. Corrections for moon's declination for like and unlike tides for all declinations and times of moon's transit.

III. Corrections for moon's parallax for all parallaxes and times of moon's transit.

IV. Solar corrections for all dates and times of moon's transit.

In predicting tides by means of these tables the algebraic sum of the quantities obtained by entering with

I. Moon's transit, upper or lower.

II. Moon's transit and declination, like or unlike tide.

III. Moon's transit and parallax.

IV. Moon's transit and date

gives the lunitidal intervals and heights of high and low water, the lunitidal intervals added to the times of transit giving the times.

A complete example requires the complete tables, the following, working back to Table I, however, shows the method, though the corrections for moon's declination and parallax are not exact.

Required the lunitidal intervals and heights on October 1, moon's upper transit 6^h, lower transit 18^h, declination 26° decreasing and parallax 54·5 increasing.

Upper transit 6^h. (Like tides.)

	H.	M.	F.	H.	M.	F.
Mean intervals and heights ...	5	11	11·3	11	37	4·0
Correction for dec. 26° d. ...		+ 17	− 0·6		+ 11	+ 0·6
,, ,, H.P. 54·5 i. ...		+ 4	− 0·5		+ 3	+ 0·8
Solar correction 1 Oct. ...		+ 3	− 0·7		+ 10	− 0·6
	5	35	9·5	12	01	4·8

Lower transit 18^h. (Unlike tides.)

	H.	M.	F.	H.	M.	F.
Mean intervals and heights ...	5	15	11·2	11	38	4·1
Correction for dec. 26° d. ...		− 2	− 0·4		+ 14	− 0·7
,, ,, H.P. 54·5 i. ...		+ 4	− 0·5		+ 3	+ 0·8
Solar correction 1 Oct. ...		+ 3	− 0·7		+ 10	0·6
	5	20	9·6	12	05	3·6

In the years 1915–16, for which the River Tyne Entrance prediction tables are calculated, the moon's maximum declination was 27°; the maximum declination is not constant, varying from 18° to 29°, and this variation affects both the mean lunar tide and the correction for moon's declination.

Lubbock's tables for London afford a means of ascertaining the change to be expected in the mean lunar tide, for when maximum declination is 29° mean is about 20°, when maximum is 18 mean is about 13; and, as Lubbock's tables are calculated for mean declination 15°, the correction then being zero, correction at 20° will give the London correction to the mean lunar tide in a year when this is the value of mean declination. The correction for London being thus ascertained, the height corrections for other ports are found from the formula:

Correction required : London correction :: range : London range

the time corrections being the same as at London.

Except in cases where the prediction tables are calculated for years of maximum or minimum lunar declination, and the tides are required for

years of minimum or maximum, the corrections, especially to the times, thus obtained are so small as to be hardly worth applying.

The correction to the declination correction is calculated, by means of two factors, on the assumption that the correction for declination varies directly with the declination.

$$\text{Factor I} = \frac{\text{maximum declination for which tables were calculated}}{\text{maximum declination of the year}}$$

$$\text{Factor II} = \frac{\text{maximum declination of the year}}{\text{maximum declination for which tables were calculated}}$$

Each declination for which the correction is required is multiplied by Factor I; the correction for the result multiplied by Factor II gives the correction to be applied. These corrections have been found satisfactory in practice, there being little, if any, falling off in accuracy from year to year.

Predictions calculated by the equation method are not exact, for some small inequalities are entirely omitted, and others are not found exactly. This method should not be used when any inequality is large in comparison with the mean lunar tide, for inaccuracies increase with the inequalities, and with large rapidly changing corrections interpolation becomes difficult. The object of the investigations resulting in this method was the prediction of tides in European waters, without the use of a machine, and by a method which could be used by the unscientific staff of the tidal branch of the Hydrographic Department, and this object appears to have been attained. With practice, the calculation of the prediction tables from observations extending over fourteen lunations is about 120 hours' work, and the prediction of tides for one port for one year about twenty-four hours' work.

The tidal requirements of seamen are not completely fulfilled by predictions alone; lack of space and financial considerations will not permit the calculation and publication of the tides for more than a very limited number of ports, or even of the prediction of the complete wave at the few ports for which the tides are calculated; simple, but so far as possible accurate, methods of extending the predicted tides to secondary ports, and of finding the height at other than the predicted times, are therefore required. The present methods of extending predictions by means of differences, and of finding the height by means of diagrams or tables based on harmonic formulæ, are far from satisfactory, and investigation should lead to improvement.

Standard ports are now chosen with very little regard to anything but their importance as ports; the choice should depend on their suitability as standards. The accuracy of tidal predictions for a standard port is of more than local importance, for the predictions are used for finding times and heights at other ports, and it will be understood that, if approximate differences are applied to approximate predictions, and an approximate

method of finding the height then used, the result may be so far in error as to be not only valueless but dangerous. It is therefore of the utmost importance that the starting-point of all navigational tidal problems, the predicted times and heights of high and low water at the standard port, should be accurate.

Tide tables for the use of seamen should thus contain:

1. Accurate tidal predictions for a number of well-chosen standard ports.
2. A method of extending the predictions to secondary ports.
3. A method of finding the height of the tide at times between high and low water.

2 and 3 should be accurate if possible, but must be simple.

It is possible that the solution of the problems of extending the prediction and finding the height at other than predicted times lies in the division of the world into "tide districts," or regions in which tidal characteristics are similar, and the prediction of the average tide of each district instead of the tides of any one port. Standard ports would no doubt lose in accuracy were this course followed, but the general gain in accuracy would be very great, and the tides of important ports might well be calculated in addition to the average tides of the district; there can be no doubt that the tides of secondary ports could be more accurately obtained by means of differences on the average tide of their district, than by means of differences on a standard port situated perhaps some miles up a river.

Discussion after the above paper:

ADMIRAL J. F. PARRY (Hydrographer of the Navy): Commander Warburg during his lecture stated that one of the essential requirements of tidal investigation was to obtain some simple formula which could be easily used by the unscientific staff of the Hydrographic Department; I do not think that Commander Warburg should apply that description to himself, as personally I consider him a true scientist on his own subject of tides. The greater part of the lecture that we have heard this afternoon has left me in much the same condition, I think, as it has left a good many of you, that is, in the main part, as being well over my head; but I specially wish to add that Commander Warburg and I have had dealings with each other for a considerable number of years, and I have the very highest respect for him and for all that he has carried out respecting tidal investigation work; I have been, of course, specially concerned with the actual working of his methods, and I know not only from my own observations and personal testing of his methods, but also from reports received from officers on board ships in a great variety of places, and especially in the North Sea, that his new method of prediction has given the most satisfactory results one could possibly hope for. It must be pointed out that in a great many cases the matter of tides is literally a question of life or death to a ship; the general public are very apt to look upon tides as a matter of interest which only concerns scientific people and does not really affect the practical man to any serious extent, but at all times knowledge of tides is most essential to the seaman: to take one example, namely

the important question of a vessel getting into port on a certain tide; the passenger probably only thinks of the mail steamer arriving in harbour in sufficient time to enable him to catch a certain train, but to the captain of the ship the matter is of very great moment; if the tide is not suitable it will mean that the ship must slow down and remain outside the harbour where she is possibly exposed to bad weather, and in war time to the additional hazards of submarine attack. Another example of the importance of possessing accurate tidal observations may also be mentioned: during the early part of the war the monitors were largely used in the bombardment of the Belgian coast, and during this work they were much exposed to torpedo attack from the sea. It was, therefore, most important that they should anchor in the shoalest water possible, so that if a torpedo was fired it would more probably strike the shoal than the ship: it was found in actual practice that the tide tables used for these calculations were so accurate that they could be depended upon to a foot. And I wish it to be most clearly understood that all the predictions for the port of Ostend, which were so largely used for the special work referred to off the Belgian coast, was the direct result of the work of Mr. Roberts, to whom the entire credit of their extreme accuracy is therefore due.

The necessity of collecting all tidal information respecting the North Sea in comprehensive form was felt very early in the war, with the result that all we already possessed, together with a considerable amount of further useful information prepared by Commander Warburg, was published in a most valuable 'North Sea Hand-book.' This little publication, which also contains information respecting the times of sunrise and sunset, times of moonrise and moonset, distance tables, etc., was probably the most largely used of all hydrographic publications during the war, being literally carried by every navigating officer of H.M. ships in the North Sea. I must again repeat how essential it is for a vessel during war-time to possess accurate tidal information: for example, if a vessel is being chased, it may be a question of life or death to her to be able to decide whether she may cross over a shoal or not, and the disadvantage of not being able to cross and having to go round the shoal is obvious to us all. During the war very rapid movements of ships were frequently necessary to cross the North Sea, and the importance of the depth to be found over a shoal at a certain time was always a most important matter. No reference to tidal work in war-time would be complete without mentioning the extreme importance of the necessity for accurate tidal predictions in connection with mine-laying. It is almost unnecessary to say that mines must be laid at exact distances from the surface, and accurate mine-laying must therefore be entirely dependent on the accuracy of the tidal predictions: it is also to be observed that the effective clearing the seas of mines and mine-sweeping generally also necessitate an accurate knowledge of tidal movements.

Commander Warburg has given us some most interesting figures, and I hope there is some one present who can speak on the subject with more authority than myself, but I again wish to emphasize that I can say from practical experience that I have proved Commander Warburg's special new method to be most successful. As Hydrographer of the Navy, and as the representative of the Admiralty in this connection, I feel that the Navy owes a real debt of gratitude to Commander Warburg for his most successful and laborious work in connection with tidal matters.

Mr. H. Wm. Thomson Roberts: I deal chiefly with the harmonic analysis by which the tide tables for the Indian Ocean were first got out before the Indian Government took over the tidal prediction machine from my father in

1904. We had done the work then for some twenty-four or twenty-five years, and when the original machine, built in 1879, was taken over, a new machine was constructed eliminating certain of the errors of the old machine and perfecting it in itself. At present, however, as Commander Warburg has pointed out, it is not perfect for river ports where shoal water is found. But where the tides are chiefly diurnal, as in the Pacific and Indian Oceans, the machine has been found a more perfect manner of predicting than the ordinary method. I am pleased to hear that Commander Warburg has discovered a better method of dealing with the North Sea tides than I have up to the present. I have been going on similar lines, to try and find out where the error exists in the machine, in order to get rid of it, which is a very curious and troublesome thing to do, because if you alter the machine in one part for certain ports you make it less perfect for others.

The Canadian Government work which we have done since about 1882 has been fairly successful, but the Atlantic port tables are not so good as the Pacific. The chief tides due to the sun and moon should be diurnal; the semi-diurnal tides are not perfect tides, and that, I think, is where the machine fails on our coasts.

Sergeant M. J. GHEURY, R.E.: Soon after enlisting I was set to observe, and predict if possible, the tides in what was to be the harbour of Richborough which the transport branch of the Royal Engineers were then creating. I was much troubled by various features, and I have brought a diagram to show the kind of things I had to deal with, selected at random from the longest series of day and night observations in which the meteorological conditions had been most favourable. The wind causes variations, so that we must limit ourselves, if we want to compare prediction and observations, to favourable conditions. One important feature is the great relative importance of the diurnal inequalities in height. Another important feature is their very great regularity, and one feels that they ought to be predictable if one only knew how. I hit upon a method of prediction after several months' trial. Calculating the middle or smoothed curve and entering every smoothed point in the observation book, it was a simple matter to deduce from each tide the difference between the smoothed value and the observed value. Sir George Darwin in his book on Tides remarks that diurnal inequality is a maximum when the moon is in south or north declination, and vanishes when the moon is in the Equator. Exactly the opposite takes place at Richborough. In fact, it is only about six or seven days after the moon passing the Equator that the diurnal inequality becomes practically nil. The diurnal inequality depends not only on the declination of the moon but also on the hour angle. At Richborough we have a very flat high water; in fact, there are two high waters forty minutes from one another, ordinarily of the same height, and the actual high water is never certain within, perhaps, half an hour, as wind may shift the time of high water. I tabulated with the declination the errors found in subtracting the actual times from the smooth values found by calculation, which gave me a table of corrections dependent simply on the declination, and neglecting the hour angle, which I might also have taken into account, obtaining a second correction in the same manner. But the result was fairly good. Even though I neglected one of the important corrections, the results were satisfactory for our requirements. I do not claim this method as the solution or even as a scientific method of predicting tides, but I think it would be suitable in many places for which there are no official predictions issued, and useful, therefore, to harbour masters, resident engineers and commercial

agents to whom even an approximate knowledge of the time would be of great use.

[*We hope to publish a fuller account of these results in a subsequent number of the 'Journal.'* ED. *G.J.*]

Mr. E. C. BARTON : It is a pleasure to hear a modern paper such as this on the subject of tides, and thereby to realize what progress has been made. On the other hand, it is a shock to learn that the harmonic methods have fallen into such disrepute. The success of the equation method appears, however, to be indisputable, and this makes us hope that the author will be able to tell us more about the new method in the near future. Notwithstanding what we have heard to-day, there can be little doubt of the reality of harmonic movements in the great ocean waters, and the downfall of the harmonic method is apparently due to the distortion of the tidal wave on passing from the deep ocean to the shallow "continental shelf." Not only is the "free period" altered, but the wave assumes a steeper front, especially where the depths decrease continuously as the land is approached or where the channel becomes narrower and produces the wonderfully high tides found on the coasts of Britain. These results are scarcely to be wondered at when we consider the transfer of energy at the point where the 2000-fathom waters of the Atlantic hand over the energy, stored in their *slow*-moving *great* mass, to the relatively *small* mass of the 100-fathom waters on the "shelf."

It would also be interesting to know whether resonance effects have any bearing on the subject of "errors." Any one who has done much experimenting in acoustics or in electrical oscillations must be impressed with the possibilities of resonance in eliminating or in reinforcing certain harmonics. Unless the resistances are of an order beyond the critical, some shallow seas and estuaries might be found to have free periods of three or even six lunar hours, and this might help to explain some of the anomalies. A study of such resonances implies tidal observations outside harbours and brings up the question of tidal recording instruments. In connection therewith I would like to draw attention to the apparatus of M. L. Favé, Hydrographical Engineer to the French Marine, which I tried to bring under the notice of the Mawson Antarctic expedition in 1913, owing to its great success on the expedition of the *Pourquoi Pas?* It remained immersed, under the ice, during periods of fourteen consecutive days and gave a continuous record on a gelatinized glass plate which rotates once in twenty-four solar hours, so that variations of lunar periodicity form traces which do not "track." The Favé apparatus has been used at depths of 450 feet, and in 1910 was used by M. Driencourt to prove the existence of Whewell's "Amphidrome" in the North Sea. The "Marégraphe plongeur," as he calls it, is described in the *Revue Generale de Sciences* of 15 Feb. 1913.

The CHAIRMAN (Sir AUBREY STRAHAN) : I think it has probably come as a surprise to many here, as it has to me, that such extreme accuracy of prediction is required. In my own experience of tides there is a considerable period of slack water, and I should have supposed that ten minutes this side or that would really not matter. But Admiral Parry's remarks throw light on that; whether you can clear a sandbank or not, and thereby escape a submarine, may be a matter of seconds and becomes an interesting question. With regard to high tide, I understand that an error of 4 feet in prediction is fatal, but in the course of the discussion it has appeared that wind may produce a difference of that amount. I do not see how allowance can be made in advance for such a factor as weather. Moreover, tides vary, I suppose, in

different parts of the world from 40 feet to less than 4 feet; so that an error would not matter as much in the one case as in the other. I take it it is really the percentage one has to work upon. The passage over a sandbank at the very moment of high tide to escape a submarine reminds me of a piece of navigation I witnessed in one of the Norwegian fiords. The vessel was a 10,000-ton steamer, and the pilot knew his depth of water so exactly that he ventured to take us across a bank, knowing that we should touch pretty heavily. He knew by the rocks on either side the depth of water within half an inch, and the problem was different to what you get in the open sea. The vessel touched so heavily as to set everything rolling, but we slid over the sandbank.

Mr. HINKS: Is the Favé tide gauge one that pumps out compressed air?

Commander WARBURG: No. We used that at one time. It was a German invention, and I do not think there is any doubt that it will be given up in favour of the Favé, which does not require a ship to remain at anchor. We have the Favé working in the Channel at the present moment. It is practically the same in principle as the barograph. It is enclosed in a steel case and lowered to the bottom, and simply registers changes in pressure. It has to be buoyed.

The CHAIRMAN: It only remains for me to ask you to pass a vote of thanks to Commander Warburg for his paper.

AIR PHOTOGRAPHY IN ARCHÆOLOGY

Lieut.-Colonel G. A. Beazeley, R.E., Survey of India

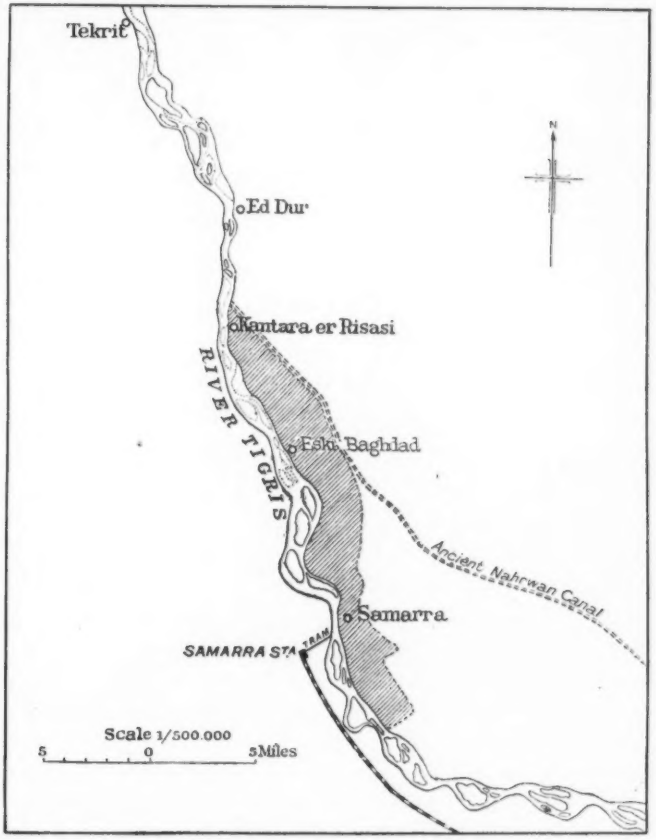
SURVEYS of areas for archæological research can in the future be greatly assisted by air photography, and I give a few interesting examples that I came across in connection with my survey work in Mesopotamia. When it was decided to carry out a 6-inch survey of the area round Samarra, Colonel Gunter, R.E., in charge of mapping G.H.Q., recommended the following procedure: first to photograph the whole area from the air; then to reproduce 6-inch scale blue prints, transfer them to the plane-table; and carry out supplementary ground survey. This was carried out, with the result that the remains of an ancient city were disclosed which would not otherwise have been discovered, in all probability. It was some 20 miles long and anything up to 2½ miles in width, and must have supported a population of about four millions.

The city was well planned, with wide main streets or boulevards, from which wide roads branched off, so that chariots could pass each other everywhere. Fig. 1 is a small section of the northern part of the city, in plan very like a modern American city; and Fig. 2 shows the central portion with its public gardens in the form of four double circles tangential to each other, with a fine pavilion in the centre.

Had I not been in possession of these air photographs the city would probably have been merely shown by meaningless low mounds scattered here and there, for much of the detail was not recognizable on the ground

but was well shown up in the photographs, as the slight difference in the colour of the soil came out with marked effect on the sensitive film, and the larger properties of the nobles and rich merchants could be plainly made out along the banks of the Tigris.

The epoch at which the city was built was still in doubt when I was in Mesopotamia, but from the remains discovered, such as gold coins



The ruined city on the Tigris around Samarra

and ornaments, pottery and "tear" bottles, it appears to have been before the birth of Christ, and may quite possibly have been passed by Xenophon in his retreat.

When riding as a passenger in an aeroplane *en route* for survey over enemy territory, I could clearly see on the desert area the outline of a series of detached forts shaped as in Fig. 3, whereas when walking over

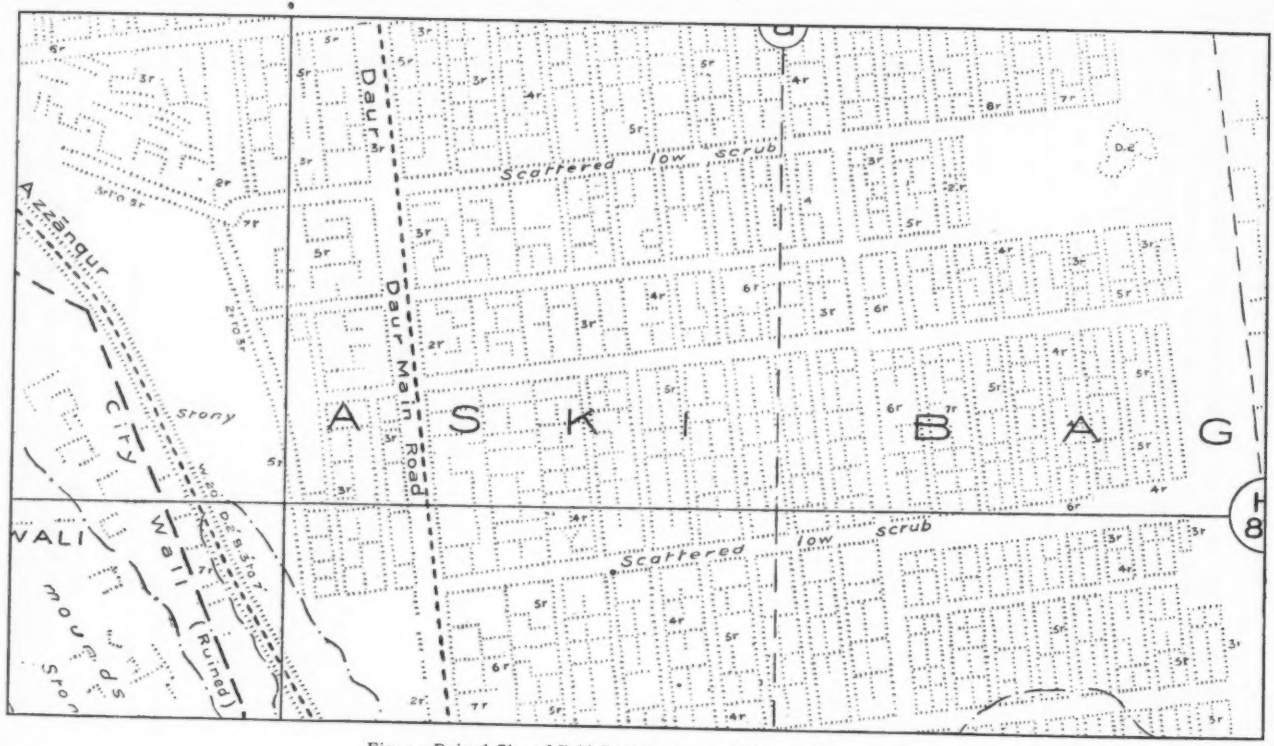


Fig. 1.—Ruined City of Eski Baghdad: part of the northern quarter

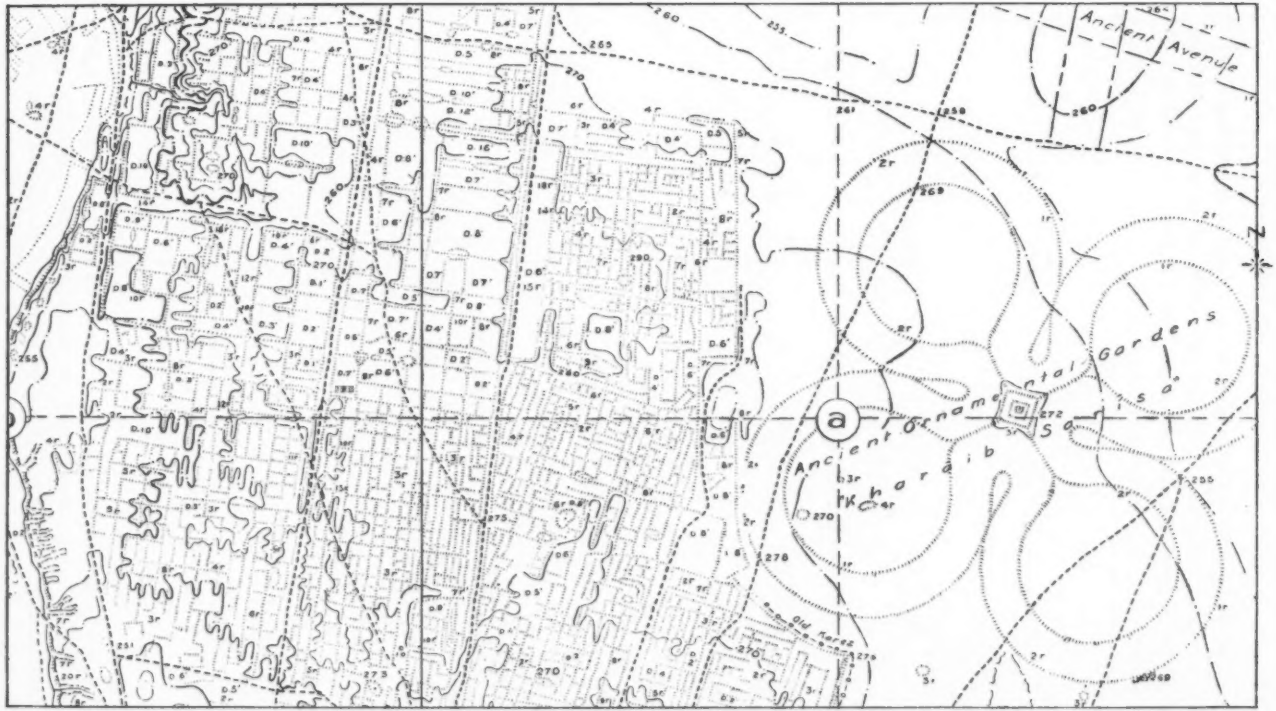


Fig. 2.—Central quarter of the City with Public Gardens

them on the ground no trace was visible. Another interesting thing I could plainly see in my flights was the outline of an ancient scientific irrigation system, such as has been introduced in the Punjab only in com-

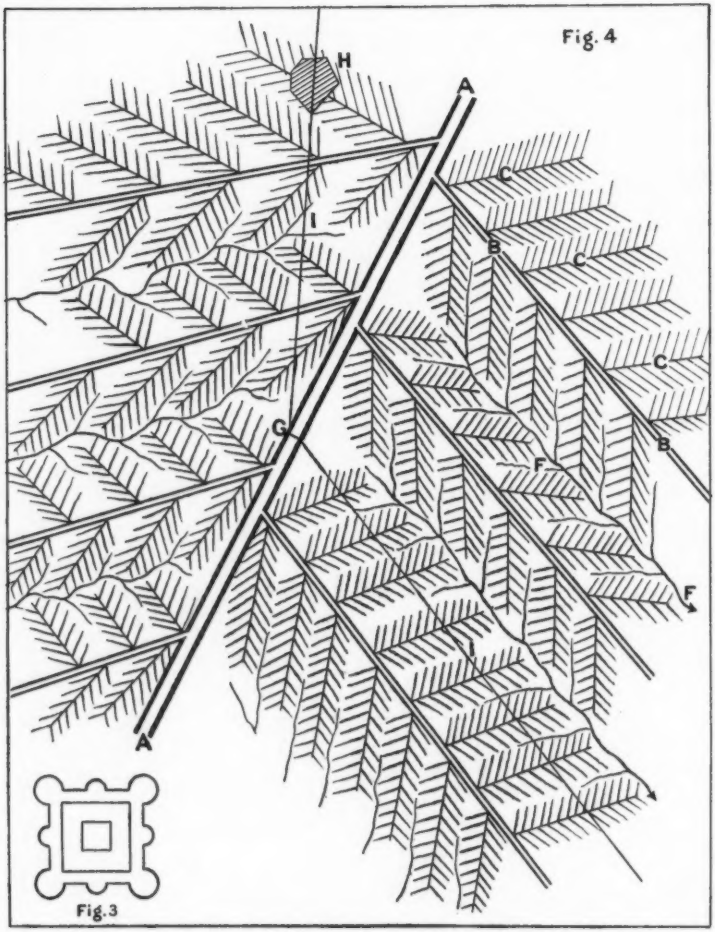


Fig. 3.—Plan of detached forts
Fig. 4.—Plan of ancient irrigation system

paratively recent years. Unfortunately I was shot down and captured before being able to make a detailed survey of the system during a lull in the military operations; but on the sketch from memory in Fig. 4 the general scheme is clearly shown. We have first of all the main canal

AA running along the highest ridge of the plain, and its main distributaries B, B running down the spurs. From these the smaller distributaries C, C, C branched off, and from them the irrigation cuts ran. Lastly come the small field cuts. All surplus water was led off along the depressions F, F and back to the canals again, so that there was no waste of water. Each tiller of the soil had his own field channel and nobody could rob him of his water. One could plainly see the main through route I I passing through the site of a village H and over the main canal by a

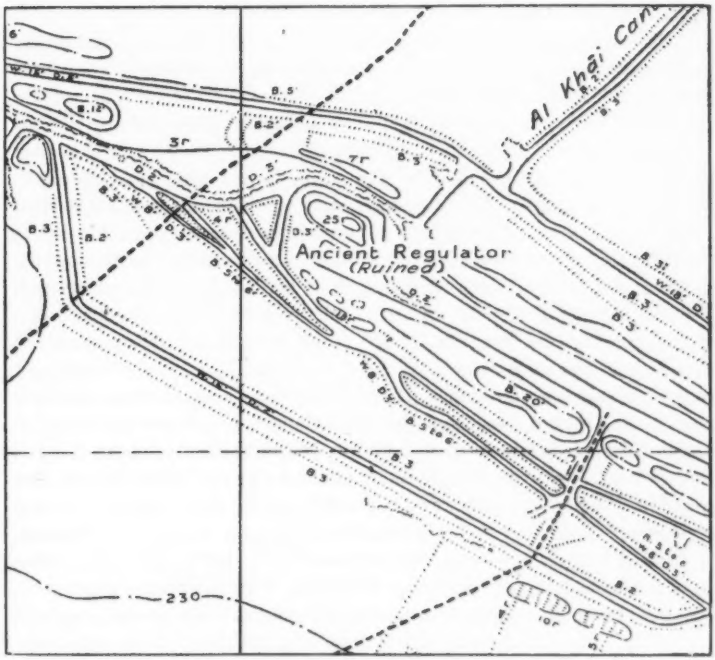


Fig. 5.—Regulator of the Nahrwan Canal

bridge G. I had the good fortune to go over the same ground in an armoured car and came across bricks at G, showing plainly that there had been a bridge there.

Fig. 5 shows one of the main regulators on the ancient Nahrwan canal. I just had time to survey and examine this personally before I was called off for duty elsewhere. I found there the remains of brick sluices and regulators, showing clearly that every channel had its regulator to control the supply. The Arabs had destroyed the masonry and carried the stones and bricks away.

WAR WORK OF THE SOCIETY

ON the fateful August Bank holiday, the day preceding the declaration of war in 1914, the President placed the personal and material resources of the Society at the disposal of the Chief of the Geographical Section, General Staff, and from that day until March 31 last, when its war work was demobilized, there has been a varied and most interesting succession of activities, of which a slight account may be given here on the conclusion of the work.

The first undertaking was the preparation of an Index to all the names on the tactical maps issued to the Expeditionary Force, for which a large staff of volunteer helpers, mostly ladies, was quickly organized. Meanwhile two officers from the Survey of India, Captain MacLeod and Captain Trenchard, with two of the Society's draughtsmen, prepared a skeleton map of the Western front required for staff work. When this was complete on the scale of 1/500,000, the suggestion was made it should be photographed down to the scale of 1/Million for further use, and this quickly led to the idea that the Society might undertake a provisional compilation of the 1/M map which had been inaugurated as an International enterprise at the Conference in London in 1909, but which had made comparatively little progress, there being for Europe only a few isolated sheets, several of which had been shown only in proof at the Paris Conference of 1913, and of which only one—Istambul, published by the G.S.G.S.—was available in quantity. After brief discussion we undertook to compile six sheets of Central Europe to be reproduced by the Ordnance Survey for the General Staff. An account of the earlier operations was published in the *Geographical Journal* for July 1915. Though conforming fairly well to the "characteristic" sheet of the International *Carte du Monde au Millionième* it differed from it in several respects, notably in that it could not, in the time available, be layer coloured. Before the original six sheets were complete others were required, and that experience was maintained throughout the work, which was the continually gratifying testimony to its usefulness. Demands, indeed, continued to increase rather than be satisfied, and the events of 1918 led to a request from one section of the War Office that the map should be extended to Vladivostok! This was impracticable; but in the course of four and a half years we were able, with the continued and devoted help of an additional staff gradually gathered together for the purpose, to compile about ninety sheets, covering all Europe with the exception of its western extremities, and extending through Asia Minor, a long way south in Arabia, and across Mesopotamia into Persia.

For the European sheets the work was, of course, that of selection and arrangement of material from the best available surveys, largely official. The original work, that is to say, the reduction to map-state of what had existed only in surveys of travellers, many of them unpublished, was con-

fined principally to Arabia; and the Arabian sheets prepared by Mr. Douglas Carruthers and his assistants stand in a class apart as original contributions to cartography. They owe much to the unpublished observations of the late Captain Shakespear and of Miss Gertrude Bell, as well as to the good offices of Commander Hogarth.

Both in extent and in success this map has vastly exceeded the anticipation with which it was begun. For all general questions of communications, supply, strategy, and politics it has proved how valuable was the original conception of the International map, on which one might proceed regularly, sheet by sheet, on an organized plan and a uniform scale so far as one might desire. The map was not treated as confidential but was put on sale, and has thus been of service to the general public; but its chief use has been seen in the Headquarters of Staffs. In one case that we remember it gradually covered a large wall and extended over the greater part of the ceiling. But its final and most gratifying success has been at the Peace Conference. At a meeting of the Geographical Representatives of the Powers at the *Service Géographique* on 6 February 1919 under the Presidency of General Bourgeois, it was decided to use this map by all nations for the preliminary definitions of new boundaries. For this purpose a layer-coloured edition covering a large part of Europe was produced by the Ordnance Survey, sheets for Asia Minor, Arabia, and Mesopotamia having been produced by the War Office from the first with layer colouring.

As sheets became available they were made the basis of studies in the representation of historical boundaries; a number of combined sheets were prepared and copies furnished to the Library of the Foreign Office and to the General Staff. They have served also for several important ethnographical studies, such as that by Mr. B. C. Wallis on the races of the late Hungarian Empire, of which a copy is available in the map-room of the Society.

When the 1/M map was well under way it became necessary to think of a general map of Africa and later of Asia. It would have required too many sheets to cover Africa on the scale of 1/M, nor was the material in most parts sufficiently good, so a 1/2M was undertaken, which had made such considerable progress by Christmas last that, with the aid of a Field Survey detachment working in the house for the first three months of the year to make the fair drawings, fourteen sheets have been finished covering Central Africa, and will soon be available. A preliminary account of this map is given in the *Geographical Journal* for October 1918.

More recently still the general map of Asia on the scale of 1/5M was begun, but of this only one sheet, Manchuria, fair drawn by one of the Society's draughtsmen, was completed when our work came to an end and all unfinished sheets were taken over by the Geographical Section, General Staff.

The compilation of these series of general maps was the most persistent

part of the Society's war work; but from time to time it was active in other directions. Five more Indexes were prepared to various series of topographical maps; some experimental work was done in the preparation of special maps for flying; and the value of the Society's library and map collection was severely tested and abundantly proved by the continual demands made upon it from almost every Department of the State, especially by the Air Ministry in the last six months. With the younger members of the staff on Active Service a heavy strain was thrown on those remaining, and it would not have been possible to support these many-sided enterprises without the ever-willing help of the ladies and gentlemen who, in larger or small numbers as occasion required, gave devoted assistance as volunteers or as members of the additional staff whose services were provided after the first year and half by a grant from the War Office. The services of the six ladies and gentlemen who served from start to finish—or nearly so—Mr. and Mrs. J. H. Reynolds, Mrs. Leach, Mrs. Rolland, Dr. Morley Davies, and Mrs. Thorp—havebeen marked by their election to the Society under Bye Laws III. 6 as distinguished for their services to Geographical science.

Besides the work for which the Society was responsible a very considerable part of the house was occupied for eighteen months by a branch of the Intelligence Division of the Admiralty Staff under the direction of Dr. Dickson. The resources of the building were thus strained to the utmost to accommodate these various staffs, and it was only by the forbearance of Fellows, who cheerfully gave up the use of a great part of the public rooms, that it was possible to carry on.

On the conclusion of the work a letter was addressed by the Secretary of the Army Council to the President and Council of the Society, by whose direction it is here printed.

War Office, London, S.W., 27 March 1919.

SIR,

I am commanded to express to the President and Council of the Royal Geographical Society the thanks of the Army Council for the very valuable work performed by the Society during the war. It was very largely owing to the assistance of the Society that it has been possible to work the Geographical Section of the General Staff with a minimum of officers, and thus to liberate for active service officers whom it would otherwise have been necessary to retain.

The work done has been continuous throughout the war, and it is impossible to enumerate it all. I am, however, to refer to the name indexes, which were prepared by the Society and which proved to be invaluable; and to the compilation of the 1/1,000,000 map of Europe and Asia, which was not only of great use during the war, but has proved to be indispensable for the work of the Peace Congress. By first suggesting this map, and then by compiling it, the Royal Geographical Society has inaugurated a work which has been, and will always be, of the greatest possible value.

The thanks of the Council are due to the whole Society, but I am to make special mention of the work of Mr. A. R. Hinks, whose great knowledge

of geographical and survey matters has been of inestimable assistance to the Geographical Section of the General Staff on innumerable occasions.

I have the honour to be,
Sir,
Your obedient servant,
B. B. CUBITT.

It will be a satisfaction to all Fellows to know that during the long years of war the Society was happily able to contribute something to the common cause, and that their efforts have been so cordially recognized by the Army Council.

NOTES ON AIR-ROUTES: I. TO SOUTH AFRICA

Communicated by the Air Ministry

AIR travel appears such a simple matter that the many and varied considerations involved in establishing long-distance aerial routes are not always realized. The needs and limitations of aircraft impose a thorough examination of a number of diverse factors, and in the case of an air-route projected across wide tracts of undeveloped country the difficulties of arriving at a correct appreciation of these factors are considerable.

The only satisfactory form of investigation is by actual reconnaissance, close observation of local conditions, covering a period of at least a year, and actual trial with the type of machine likely to be used. This system alone is, however, not only slow but extravagant. The development of a route, accordingly, has to pass through three successive stages:

1. A close study of all available authorities in order to obtain some idea of the line of least resistance from an aviation point of view.
2. Having decided upon the general line to be followed, it is necessary to select the actual aerodromes, landing grounds, refuelling and repair bases.
3. When these have been selected at suitable intervals, blazing a trail by actual flight.

With regard to the first of these stages, the chief difficulty is that however excellent the existing reports, gazetteers, and maps available may be, not one of them is compiled with the possibility of aerial travel in view. The result is that the gleaning of relevant material involves considerable research, and of course much of the information desired is not to be found at all. It is therefore sometimes rather a problem, not only to appreciate the best line for an air-route to take, but to decide to what degree it is a practical proposition.

In the first place, an air-route can be established only upon a system

of bases, each one of which must be served by transport which is able to cope with the quantity of petrol, oil, stores, spares, etc., required.

The sea, a navigable river, a railway, or a road fit for heavy traffic is consequently an essential. In the selection of the actual landing grounds much time and possibly expense may be saved if sufficient information is available to enable us to judge whether any given locality is suitable or not for a landing. For an aeroplane we must know the dimensions, the surroundings, and whether the surface is good all the year round. An aeroplane landing ground should allow a clear run of at least 800 yards in any direction, where the surroundings are clear of obstacles, and 1000 yards if there are trees, houses, or hills in the vicinity. (Aircraft must always land or take off against the wind.)

The surface must be such that sufficient ground speed to take the machine into the air can be obtained, so that a smooth hard surface free from ditches and banks is essential. Then it is useful to know what storage and repair facilities are available in the vicinity and the means of transportation to and from the aerodrome. Telephonic or wireless communication is also an important point. For a seaplane we must know the expanse and depth of water available for landing and getting off. A flying boat requires a run of 800 yards against the wind, with a further space free of high obstacles. A minumum depth of 6 feet is also necessary to get up speed. Seaplanes require shelter from the wind when moored, also facilities for landing them, either a convenient beach or slipway. The state of the air in the neighbourhood of a proposed landing-ground is also an important point. In the neighbourhood of high hills and deep valleys sudden gusts sometimes make flying almost impossible, and in tropical climates air disturbances below a certain height are sometimes a source of danger.

Unfortunately a forced landing cannot entirely be left out of our reckoning, and the nature of the country over which the flight is to be made must be considered, as well as the possibility of prompt repairs to the machine and succour to the crew.

Among other requirements, an air-route should be provided with a system of wireless stations, so that a machine is in wireless touch throughout its flight. This is necessary for navigation and to call for help in case of trouble. A series of meteorological stations in wireless touch is also necessary, so that machines can at any time be given information regarding existing weather conditions.

To take as an example the Cairo to Cape route, now in the second stage of development. From Cairo to Kosti, by following alternatively the Nile and the railway, favourable conditions are found; but south of Kosti, as we approach the Dar el Funj district, we come to a forest region, and the Nile banks become either wooded or marshy. When the Sudd region is reached conditions become worse and practically impossible. The line of the White Nile is thus not suitable for a land machine.

Certain alternatives present themselves, such as, for instance, a route passing *viâ* Sennar up the Blue Nile to Roseires, thence south, skirting the Abyssinian frontier, to Gambela and the western shore of Lake Rudolf; but the lack of communications place these alternatives out of court. A route passing from Roseires to Nasser on the Sobat and thence to Gondokoro might be practicable during the dry season, thus taking advantage of the Blue Nile and the Sobat as communications. Nasser is 230 miles south of Roseires; from Nasser to Gondokoro is 260 miles and to Bor 180, but the intervening country is deficient in communications, and cannot be regarded as promising from a forced-landing point of view. From Gondokoro there should be no difficulty in reaching the eastern shore of Lake Albert in the dry season, although it is questionable whether it would be practicable during the rains.

For a land machine, therefore, the air-route from the line Kosti–Sennar to Kondokoro bristles with difficulties, and it is for consideration whether the seaplane is not a more suitable type of machine to use over this section. Through the Sudd region, however, the maximum width of the main channel cut for steamers is 300 yards, and as in the dry season the surface wind is inclined to be easterly, there may be difficulties about getting off. It is possible that bends in the channel may enable us to overcome this difficulty, but this is a matter only to be satisfactorily cleared up by actual reconnaissance.

Between Gondokoro and Dufile there are the 100 miles of rapids, but the distance is not sufficiently great to make this an insuperable obstacle. Between Dufile and Lake Albert and from above the Murchison Falls to Lake Kioga, a seaplane should be able to land and get off again without difficulty. From Lake Kioga to Lake Victoria there is another 95 miles of bad water to pass over, but this again is for a sufficiently short distance to make it worth risking. It will be noted that Gondokoro is the limit of the line of supply running from north to south. Bases south of Dufile will be served by the Uganda Railway, Lake Victoria, the Busoga Railway, and the Nile itself.

From the northern portion of Lake Victoria the route as at present decided upon is to pass to Mwanza, which can easily be reached by seaplane over the lake, or by land-machine flying over northern and eastern Kavirondo. From Mwanza it is the intention to fly to Kigoma on Lake Tanganyika and the terminus of the central railway. This involves a flight of 300 miles over a country without roads, but once Lake Tanganyika is reached, Abercorn is attainable by air, either by seaplane as far as Kituta or by a land machine along the eastern littoral of the lake.

From Abercorn to Broken Hill is the next stage, and the air route will follow one of the motor roads that run from Kasama. The westerly of these two roads will probably be followed, in spite of its passing through Congo territory, as the road through Mupika and Serenje passes through country that is more heavily wooded. From Broken Hill it is proposed to

follow the railway through Bulawayo, Mafeking, and Kimberley to Cape Town, this section of the route being comparatively plain sailing.

As far as possible it is advisable to provide landing-grounds at intervals of some 200 miles. Each of these requires a proportionate supply of petrol and stores, upkeep, and due provision for trained personnel, so that the organization involved in an air route can be realized.

Various alternatives to this route present themselves. When the country is more developed and communications improve, the upper Nile Valley can be avoided by flying from Port Sudan to Aden *viâ* the islands of Farsan, Kamaran, and Perim. Thence to Addis-Abbaba along the railway, and from the Abyssinian capital *viâ* Lakes Abaya and Stefanie, the western shore of Lake Rudolf to Londiani on the Uganda railway.

From Lake Victoria an alternative is to fly along the Uganda railway, from Kisumu to Naivasha, thence *viâ* Magadi to Arusha, which is only 40 miles from the railway terminus at Moshi. From Moshi the subsequent stages might be Kondoa Irangi, which is connected by road with the central railway; Dodoma on the central railway; Iringa, connected by road with Kilossa on the central railway; from Iringa *viâ* Neu Utengule to Ikoma on the Stevenson road, and from Ikoma to Kasama. The advantage of this line is that it covers what is, for Africa, comparatively good flying country. Generally speaking, the surface of Central Africa is most unfavourable for a forced landing. Bush, forest, swamps, lava beds, and steep hills seem to predominate; and even when open steppes are found these are in many cases inclined to be water-logged in the rainy season. In certain types of bush country open spaces exist, and in the dry season when the grass is short, possible emergency landing-grounds would be available. In the wet season, however, when the grass is long and the surface soft, it is difficult to see how, even though a successful landing were made, the machine would ever get off again. Anthills common in certain parts of Africa constitute another obstacle in many localities otherwise suitable.

With regard to meteorological information, many important points at present remain in doubt. The region of thunderstorms in the neighbourhood of the great lakes constitute a drawback, but not an insuperable one, and one of the advantages of the Lake Rudolf–Arusha–Dodoma line is that it avoids these on the one hand and the full strength of the south-west monsoon on the other. If we knew more about the upper winds it would greatly assist us in solving various problems. What is the state of the upper wind during the monsoons? How high must we climb before reaching a strata of comparatively calm wind? Questions such as these cannot at present be answered, although they vitally affect air travel.

The difficulties already indicated give some idea of the nature of the problems to be faced before air-routes can become at all universal, and other routes, such as those to India and Australia, have their own particular problems. We are therefore forced to proceed slowly and care-

fully in establishing air-routes, and the fact is emphasized that air travel is not merely a question of getting in a machine and flying anywhere our fancy takes us.

In forwarding at our request the above notes for publication in the 'Journal,' the Air Ministry say that they will be grateful for any information, remarks, or criticism from Fellows of the Society.—ED. *G.J.*

REVIEWS

EUROPE

The Cradle of the War: The Near East and Pan-Germanism.— H. Charles Woods. With a Foreword by **A Lawrence Lowell**, President of Harvard University. Pp. xix. and 360. *With Maps and Illustrations.* London: John Murray. 1918. 12*s. net.*

DURING the winter of 1917–18 Mr. Woods delivered a course of lectures on "War and Diplomacy in the Balkans" before the Lowell Institute at Boston, and the present book is based upon the material used in these lectures. It has been printed in America, and the Preface and Postscript are dated respectively 11 July and 15 July 1918. The delay in reaching the public here, though doubtless inevitable under present conditions, is nevertheless regrettable; for, as the dates show, the book was passed for press just at the beginning of the period when triumphant success—so long withheld—began to attend the arms of the Allies, leading up, with startling suddenness, to the Armistice of November 11. The contents are largely, but not exclusively, historical, and not only do we now look back to the past with different eyes, and with already, owing to the partial lifting of the veil of censorship, fuller knowledge, but the future, of which Mr. Woods naturally says a good deal, has taken on a different aspect. Nowhere, perhaps, is the latter fact more apparent than in connection with the western side of the peninsula. Mr. Woods appears to look forward to a Serbia enlarged only by a union with Montenegro and an absorption of Bosnia and Herzegovina, and thus his proposals as to an Albania established under the protectorate of Italy are uninfluenced by the difficulties connected with boundary-drawing between Italy and Yugo-Slavia further north. Naturally also, in view of the date when the book was written, the new conceptions associated with the League of Nations find no place within it.

The author states as his main purpose the attempt to prove that a peace which would leave Germany in control throughout the Near East would be disastrous to the world—a point which has now happily been settled. He begins by giving a concise account of events in the Balkans and the adjacent areas in the period prior to the outbreak of the war. This introductory chapter is followed by a series of others in which the different states (including Rumania) are discussed in relation to the war. After these chapters we have others dealing with the Military Highways of the Balkans (based upon the paper published here by the author), with the Dardanelles and Salonika expeditions, with the Baghdad railway (again based upon Mr. Woods' paper in this *Journal*), while a final chapter, under the heading of "Mittel-Europa," discusses German aims, and the best methods of ensuring future peace in the Balkans. The maps of the Baghdad railway, it may be noted, are already out

of date, as may be realized by comparing them with that which the *Times* has been permitted to publish since the armistice.

Despite the changes which have occurred since the book was written, it will fill a useful place in war literature as a summary of recent Balkan history, and of those broad geographical features which have had most influence on history. Incidentally we may notice that Mr. Woods takes a more favourable view of Bulgaria's actions than many other authors, and appears willing to give a general acceptance to her national claims in Macedonia, so fiercely contested by Serbian authors, and in the Dobruja, equally contested by the Rumanians (cf. M. Comnène's 'La Dobrogea'). He would grant Bulgaria a considerable extension of territory, even at the expense of both Greece and Serbia.

M. I. N.

Wasserstandsbeobachtungen an den Kusten Finlands.— Edv. Blomqvist und Henrik Remqvist. Helsingfors: Druckerei des K. Senats. 1914.

The director of the Hydrographical Bureau publishes in these pages the readings of twelve tidal gauges placed along the coast of Finland from Viborg to Toppila near Uleaborg, these readings in six cases extending over a period of twenty-four years. Tables are also compiled of the means for the years and months, and from the mean heights of the water for the years a map is compiled showing the uplift of the land. This shows some divergence from the map of R. Sieger in the *Zeitschrift der Ges. für Erdkunde*, 1893, especially in the neighbourhood of the Åland Isles, but, like it, indicates a greater upheaval to the north. A comparison with earlier calculations seems to prove that there is a retardation in the rise of the land, but the earlier observations are somewhat doubtful. Some of the readings published in this volume are also affected by the same cause, the zero point of a scale not having always been accurately controlled when the scale has been removed, or the foundation has sunk. The normal zero for Finland is that of the gauge in the Skatudd Canal at Helsingfors, and the differences between this and the Berlin, Swedish, Kronstadt, and Danish zeros are given.

ASIA

The Playground of the Far East.— Rev. Walter Weston. London: John Murray. 1918. Pp. xii., 333. *Two Maps, Twenty Illustrations.* 18*s. net.*

Mr. Weston's explorations in the Japanese Alps are well known to Fellows. He has often lectured before the Society, and was awarded the Back Grant in 1917. It is over twenty years since he described his earlier explorations in "Mountaineering in the Japanese Alps." The present book contains the record of later journeys, together with a number of miscellaneous studies. An introductory chapter furnishes a concise account of the outstanding characteristics of the ranges in Central Hondo, which Mr. Weston has christened the Japanese Alps. Two chapters are devoted to the "Annals of Fuji-san," and half a dozen chapters to Mr. Weston's travels in the northern and southern ranges. Other subjects treated are mountains and mankind in Japan, the making of the Japanese soldier, Japanese sports and pastimes, the seasons in rural Japan, and a comparison between modern Japan and ancient Greece, bringing out the parallelisms of their scenery, superstitions, folklore, and social life.

Mountaineering has become very popular among the Japanese themselves in recent years. The Japanese Alpine Club (Nihon Sangaku-kwai), which was founded in 1906, now has some 750 members, drawn mainly from the educated

classes. Similar but smaller clubs have been formed, representing the mountain provinces of Central Japan and the universities and high schools of Tokyo and Kyoto. In 1912 the Alpine Club of Formosa was founded under the presidency of the Civil Governor of the island, and Mr. Weston notes that the highest peak in Formosa (Mount Morrison) has been renamed Nii-taka-yama, or "new loftiest mountain," as its altitude (13,080 feet) overtops that of Fujisan, "the peerless peak," by some 700 feet. There is danger that this new popularity of mountaineering among the Japanese may degenerate into love of merely sensational and record-breaking achievements. Both in 1913 and in 1917 one of the leading newspapers in Tokyo organized a competition for the ascent of Mount Fuji, with considerable money prizes for the winners. The Japanese Alpine Club, however, is striving to maintain a high standard among its members, and its journal contains much excellent matter, some of which will in future be accessible to English readers, as it has been decided to include in it an English section edited by Mr. H. E. Daunt.

In connection with his own travels, Mr. Weston discusses the alleged traces of glacial action in the Japanese Alps, particularly in the northern range, and arrives at the conclusion that those who support the glacial theory have not made out their case. On the present evidence, he thinks, the verdict must be "not proven." S. C. G.

Palestine of the Jews, Past, Present and Future.— Norman Bentwich. London: Kegan Paul, Trench, Trubner & Co., Ltd. *With a Sketch-map of the railways of Palestine.* 1919. *6s. net.*

This book, written the writer tells us "during the leisure hours of camp life in the summer of 1917 while waiting at the portals of Palestine to enter the Promised Land," appears to have been carefully edited for publication by the writer's relatives. It contains an excellent series of essays on geographical and historical questions relating to Palestine. It advances the Zionist cause with a breadth of view and moderation which must elicit wide sympathy. The author is full of hope of seeing the land of his affection restored once more to its former prosperous condition, and quite rightly recognizes that "agriculture has remained from Biblical times the chief pursuit of the inhabitants, and for some time to come the economical development must be largely agricultural. The experience of the Jewish settlements has proved that the ancient fertility of the country may be completely restored by an industrious and intelligent population." There are great possibilities in the irrigation of the Jordan Valley. "From Tiberias to the Dead Sea there is a fall of 10 feet a mile, and it is estimated that in that stretch of 80 miles, fifty dams could be erected for the irrigation scheme. From each such lake water would be drained out, with high-level canals contouring the hills and giving perennial irrigation to the hot-house of the Jordan Valley, which would become the greatest productive district in the world." Whether the Dead Sea is "an untapped reservoir of chemical wealth," and whether oil actually exists (in workable quantities) east of the Jordan, and whether, still more, there is coal in the desert of the Negeb, are at present mere subjects of speculation. Few modern students of geography would accept the calculation made, it is here stated, by the late Colonel Conder, R.E., that Palestine "at one time supported at least ten million people." While, however, offering criticism of minor points we would add that this is a most readable little book, which all those interested in Palestine "past, present, and future," would do well to study.

E. W. G. M.

Palestine, Mesopotamia, and the Jews. The Spiritual Side of History.—Sir Andrew Wingate, K.C.I.E. London: Alfred Holness. 1919. *Sketch-map and* 10 *reproductions from photographs.* 5*s. net.*

Though covering a wide field—modern political history, physical geography and Biblical interpretation—the main thesis of this book seems to be that the events of the last few years reach their culmination in "the return of the Jews to Palestine." It is the work of a seer or mystic, and through it all runs a thread of faith in better things to come which must necessarily commend it to those who accept the author's interpretations. Naturally the author accepts without dispute that all Palestine is to be Jewish. But even our occupation of "Mesopotamia" is part of the general plan. "To the question, how can Mesopotamia be rapidly peopled? the answer is, By the Jews. In south-west Russia and Rumania there are some six million Jews, sending forth an increasing stream of emigrants in search of life under happier conditions. These can furnish both the labour and the population required." "The irrigation of Mesopotamia will withdraw her Jewish population from the Pale." The author would like to see the peace treaty signed in Jerusalem. There is much, however, of more mundane interest—well worth reading too—in the chapters bearing upon recent political events, in the account of Sir William Willcocks' irrigation schemes in Mesopotamia, and in the brief but lucid account of the main geographical features of Palestine. Of the illustrations the most interesting are those taken on the Euphrates by Sir John Jackson, Ltd. A carefully constructed "Synopsis of the War" at the end of the volume should prove useful to the general reader. E. W. G. M.

A Bibliography of Indian Geology and Physical Geography, with an Annotated Index of Minerals of Economic Value.— Compiled by **T. H. D. La Touche, M.A., F.G.S.**, Fellow of the Asiatic Society of Bengal. Published by order of the Government of India. Calcutta: sold at the Office of the Geological Survey of India, 27, Chowringhee Road. London: Kegan Paul, Trench, Trübner & Co. Part I. [1917]. Pp. xxviii. and 571. *Price* 4 *rupees*, or 5*s.* 4*d.* Part II. [1918]. Pp. ii. and 490. *Price* 4 *rupees, or* 6*s.*

This most valuable work of reference is an illustration of what can be done by a retired official in the greater freedom of his life. Based mainly on Mr. R. D. Oldham's MS. bibliography of 1888, it draws additional information from the chief English libraries, and may claim as near an approach to completeness as any human undertaking can. The first volume is the Bibliography. On this the only criticism we have to make is that there is no precise statement as to the limits of time or space of its subject-matter. On internal evidence we should judge that all works published up to the end of 1915 are included. We note some works in the list, the titles of which refer exclusively to Ceylon; but whether they owe their inclusion to their containing references to India, or whether the bibliography is intended to cover Ceylon, is not made clear. Probably the former is the case, but the absence of a definite statement might mislead an investigator of some subject relating to the island.

The second volume is an annotated index of minerals of economic value, and should at once become a standard work of reference for Indian minerals. Every known occurrence of a useful mineral is recorded, with references; geological details, methods of working and statistics of output (up to 1915) being given in all important cases. Here much interesting reading may be found. We can learn the story of the wonderful rise of manganese mining,

starting less than thirty years ago and now at the top of the world's output. We can read of the primitive native methods of iron-smelting or of the preparation of salt and saltpetre. We may learn something of the first effects of the war, as that the stoppage of salt imports from Germany and Asiatic Turkey was largely balanced by increases from Egypt, Spain, and the United Kingdom. The subject-matter in general may be dry, but there is a touch of humour under "Mercury," for the occurrence of which metal in India there is no satisfactory evidence :—"Those accounts which do not owe their origin to the accidental breaking of a barometer tube, or perhaps to the escape of mercury from a dispensary, refer . . . to localities which are difficult of access."

These two volumes should find a place in every important reference library. H. M. D.

AMERICA

Vagabonding down the Andes.— Harry A. Franck. London: T. Fisher Unwin. [1919.] Pp. xi. and 612. Map and 175 illustrations. 25*s. net.*

This is the English edition of an American book, published in 1917, containing a day to day narrative of the author's experiences and impressions during four years' travels in South America. From previous writings, Mr. Franck is known as a lonely wanderer who has tramped through many lands. Much of the country he traversed in South America would not permit of any other mode of travel. Now and again he made use of trains and river steamers, but long distances in the interior were covered on foot. Starting from the Atlantic coast of Colombia, he made his way up to Bogotá, and from there tramped over the Quindio Pass (11,400 feet) of the Central Cordillera to Quito. After spending some months in Quito, he continued his journey through the Andes to Cuzco, whence a hazardous excursion took him to Machu Picchu, an old stronghold of the Incas, now almost buried in vegetation and seldom visited by travellers, though surveyed a few years ago by the Yale Peruvian Expedition under Prof. Hiram Bingham. Having returned to Cuzco, he pushed through the heart of Bolivia to the borders of Brazil, and finally made his way to Buenos Aires down the Paraguay and Uruguay rivers. He attempted no geographical discoveries, but the record of his peregrinations affords an interesting picture of the less familiar aspects of life and travel in South America. Mingling with the poorer classes of the population, assuming their dress, and generally adopting their ways of living, he gained an intimate knowledge of their characteristics and customs. He is frankly not very favourably impressed with the average South American Indian. Mr. Franck possesses a breezy literary style, combined with a faculty for vivid description, and the story of his experiences makes entertaining reading.

S. C. G.

AUSTRALASIA

Thirty Years in Tropical Australia.— Rt. Rev. Gilbert White, D.D. London: S.P.C.K. [1918.] Pp. viii. and 264. *Maps and Illustrations.* 10*s.* 6*d. net.*

The thirty years of which Dr. White writes extended from 1885 to 1915. As a young priest he went out from England to North Queensland, and after working there for fifteen years was consecrated as first Bishop of the diocese of Carpentaria. He resigned this charge in 1915 to become Bishop of another newly formed diocese, that of Willochra, in the backblocks of South Australia. Such a record implies a strenuous career and much travelling in remote districts. Long journeys in the interior (including one across Australia from north to

south) and hazardous coastal voyages have provided the bishop with material for a volume of reminiscences which not only makes excellent reading but is distinguished by its shrewd comments on conditions and problems in tropical Australia. Without dwelling on the hard conditions of the life Dr. White gives a vivid impression of the difficulties attending day to day travel in these regions, quite apart from anything in the nature of exploration. On the White Australia question, while sympathizing with the underlying principle, he does not think that the northern parts of Australia can be fully developed by white labour, and is dubious of the wisdom of a "dog in the manger" policy. A colour line might, he thinks, be drawn across the continent without the evil effects which are popularly feared; but he recognizes that public opinion in Australia is opposed to such a plan. An instructive chapter is devoted to aboriginal life. Dr. White disputes the classification which puts the Australian black fellows among the lowest types of humanity, and he finds in their language and customs many suggestions that their former civilization reached a higher standard. Some years ago, in a lecture before the Royal Geographical Society of Australasia, he elaborated a proposition that, if the Government were to establish mission stations in the far north, connect them by telephone, and train the natives to report the presence of strangers, any hostile landing would at once be detected, and one of the dangers presented by the great empty spaces of tropical Australia would cease to exist. The adoption of such a scheme, he points out, would have saved the Commonwealth military authorities much anxiety during the earlier stages of the war. A chapter on pearl shelling in Torres Strait is contributed by Lieut. K. O. Mackenzie, whose long acquaintance with the industry as a resident sheller in the Strait has enabled him to furnish much practical information on the subject. S. C. G.

GENERAL

My Reminiscences.— Fanny, Lady Blunt. London: John Murray. 1918. Pp. xviii., 316. *Two portraits.* 15*s. net.*

This is an entertaining volume of reminiscences by the lady who wrote 'The People of Turkey' over forty years ago. It is redolent of the Turkey of last century. Lady Blunt was born at Therapia in 1840 and spent the early part of her life at Brussa, where her father, Mr. Donald Sandison, was appointed British Consular Agent, and where for a time he was the only foreign representative. On her mother's side she is of mixed Persian and Italian descent, and one of her cousins was Sir Edward Zohrab, who became Under-Secretary of War in Egypt. Her husband had also many family connections with the Near East. His father was British Consul at Smyrna, and he himself held several consular appointments in Turkey before being transferred in 1872 to Salonica, where he remained, first as Consul, then as Consul-General, till 1899. These particulars will suffice to show the range of Lady Blunt's reminiscences. They are mainly in the nature of personal anecdotes, and throw some interesting side-lights on men and politics in Turkey in the latter half of the nineteenth century. Once, when travelling from Salonica to Constantinople on board a Russian ship, she insisted on going ashore with the captain at Mount Athos, and claims to be one of the only two women who ever evaded the vigilance of the monks, the other being Lady Stratford de Redcliffe. In an introduction to the book Admiral Sir Rosslyn Wemyss, as one of the naval officers who formerly enjoyed the hospitality and counsel of "Aunt Fanny" at Salonica and was admitted into the circle of her "extraordinary nephews," pays tribute to the long and valuable services of the late Sir John Blunt and Lady Blunt in the Near East. S. C. G.

THE MONTHLY RECORD

EUROPE

Snow in the French Alps.

AN admirable summary of our knowledge of the conditions of snowfall in the French Alps, and of its influence on the economic life of the people, is contributed to vol. 5 (1917, Fasc. iv.) of the *Recueil de Travaux de l'Institut de Géographie Alpine* (Univ. de Grenoble) by Mons. E. Bénévent, already known for his valuable studies of rainfall in the south-east of France. It is only within the past twenty years that really careful and sufficient observations of snowfall have been made in the French Alps, mainly through the instrumentality of M. Mougin, and even these concern the northern part of the range only, the data for the southern Alps being still extremely scanty. The Meteorological Commission of Haute-Savoie has however given attention to the phenomenon since 1876, and though the observations have lacked the scientific rigour now demanded by students, M. Bénévent has found them useful as at least supplying indications of the *depth* of the snowfall. He attaches more importance to the measurement of the precipitation in its solid form than does M. Mougin, who in his studies of snow in Savoy takes account almost solely of the amount of water produced by melting. M. Bénévent points out that the water reserve supplied by the snow is far from being the only geographical consequence of the phenomenon, the thickness of the snow-covering playing an important *rôle* in Alpine life, as he shows in his instructive summary of conclusions. In the earlier parts of the paper he discusses carefully the conditions of snowfall, and its distribution both in time and space as influenced by the relief and general character of the region. He brings out clearly how the same important differences between the northern and southern sections of the French Alps are traceable as regards snowfall, which he had previously established in the matter of the general precipitation. In the moister northern group oceanic climatic influences predominate, while the southern group is subject to the Mediterranean *régime*. In the north, exposed to the moisture-bearing winds from the south-west, it is the outer Alps ("Préalpes") which show the greatest amount of snowfall, while in the corresponding part of the southern group the amount of snow is at its minimum, the maximum occurring here in the south-east—the direction of the prevailing winds in this section. Hence one of the reasons for the great differences between the economic conditions in the two sections. It is impossible to follow M. Bénévent into the details of his masterly analysis of the local variations due to topography, considered under the main headings of quantity, frequency, and duration of the snow-covering. The geographical distribution is found to vary, like that of the rainfall, with the altitude, aspect, and distance within the range, but here, as is natural, the importance of altitude is enhanced by the cooling effect which it produces. A fact which is well brought out is the difference in the seasonal distribution at different levels, for whereas below a certain limit there is a mid-winter maximum, in the highest parts there is a minimum at the same period separating two distinct maxima. It is the duration of the snow-covering which has the most important influence on the economic life of the people, which in the parts where the snow lasts five or even six months is entirely governed by the necessity of providing in summer for the needs of the long winter, since communications may be entirely interrupted with the sources of supply in the lower country. Agricultural operations are also largely at the mercy of the snow, which may cause serious

damage either at seed time or harvest. Even the types of buildings show the influence of the snow conditions from the need both of strengthening the roofs to enable them to support an excessive weight and of providing storage for the large quantities of fodder necessary for the winter supply.

ASIA

Earthquake in Assam on 8 July 1918.

A destructive earthquake occurred in Assam shortly before 4 p.m. on the above date and was felt throughout that province, in Eastern Bengal, and over most of Burma. According to Dr. M. Stuart (*Records Geol. Surv. India*, vol. **19**, 1918, pp. 173–189), the epicentre was situated among the Balisera Hills, about 45 miles south of Sylhet. Though there were at least two foreshocks (on July 2 and 7), the main earthquake came without warning. The casualties were, however, small, owing to the time of occurrence. The area of greatest intensity was oval in form, about 20 miles long and 10 wide, and within it hardly any brick buildings escaped destruction. Dutton's method gives the depth of the focus at about 8 or 9 miles.

AFRICA

Ethnological Expedition to British East Africa and Uganda.

A project advocated for some time past by Sir James G. Frazer, though hitherto delayed by lack of funds, is now on its way to fulfilment thanks to enlightened generosity by Mr. P. Jeffrey Machie (of Machie & Co., Glasgow), who has placed the necessary funds at the disposal of the Royal Society. It has been felt that careful researches into the laws, customs, and beliefs of the native tribes under British rule in East Central Africa, particularly Uganda, would not only be a valuable contribution to Ethnology, but by giving an insight into the habits and ideas of the subject populations would also conduce to the good government and economic development of the regions in question. An expedition for this purpose has now been organized and placed under the leadership of the Rev. John Roscoe, M.A., Rector of Ovington, Norfolk, and for twenty-five years a missionary in East Africa under the C.M.S. Mr. Roscoe, who has an intimate knowledge of the languages and customs of the native tribes of East Africa, is already well known to ethnologists for his two excellent books—'The Baganda,' published in 1911, and 'The Northern Bantu,' published in 1915, both of which were reviewed in the *Journal* (vol. **39**, p. 146; **47**, p. 56) on their appearance. During the present expedition, which may last two years, he will devote special attention to the pastoral life of the people, and it is hoped that some practical results of importance for the cattle-breeding industry of East Africa may be gained. If possible researches will be made also among the Akikuyu, Gallas, and the cannibal tribes of Mt. Elgon. Mr. Roscoe, who also hopes to make botanical collections for Kew, was to leave Birkenhead during April, and the expedition will make its final start from Mombasa, proceeding through East Africa to Uganda and down the Nile to Khartum and Egypt.

AMERICA

Early Railway Surveys in the Canadian Rockies.

When, in 1871, British Columbia decided to enter the dominion of Canada, and the construction of a railway to unite that province with the east of the Dominion was resolved on, a first step towards the realization of the project

was the survey of a feasible route through the Rocky Mountains and neighbouring ranges. The work was taken up energetically and for several years parties were at work examining all possible routes across the mountains. The surveys added greatly to the geographical knowledge of this part of Canada, but after the final selection of the route followed by the Canadian Pacific *viâ* the Kicking Horse Pass, much of the work done in other directions passed out of notice and never became fully available to the general public. Mr. Howard Palmer, himself known for his mountain explorations in this part of Canada, has done good service by supplying a connected account of the various surveys from 1871 onwards, in the *Bulletin of the Geographical Society of Philadelphia* for July 1918. Among the most energetic of the surveyors was Mr. Walter Moberly, who had already distinguished himself by discovering the Eagle pass over the Gold range west of Revelstoke in 1865, but whose exploits have hitherto been hardly so well known as they deserve to be.* The line of approach to the mountains from the east originally contemplated for the railway was from Edmonton either by the North Saskatchewan and the Howse Pass or by the upper Athabasca and the Yellowhead Pass, and surveys were at once begun in both directions. Were the more southerly Howse Pass to be selected, the chief problem would be the crossing of the Selkirks within the great bend of the Columbia so as to avoid the great *détour* by this bend, and Mr. Moberly won the distinction of being the first to cross this range, though by a route further north than that eventually selected. The more northern surveys were directed to the line from the Yellowhead pass to Tête Jaune Cache and across by the Albreda pass to the North Thompson River, which, in the event of the Yellowhead route being selected, would have been followed down to Kamploops at the junction with the southern route. In 1872 the Yellowhead route was officially chosen—prematurely, as it now seems, in the idea that the Selkirks formed an insuperable obstacle—and it became necessary to transfer the whole camp and equipment of one of the parties from the upper Columbia to the Yellowhead by the Athabasca pass—a task of much difficulty which Mr. Moberly successfully accomplished, adding otherwise to our knowledge of the country along this line, and locating for the first time the source of the Fraser River. For several years much of the energies of the surveyors was given to the search for the best route west or south-west across the formidable barrier of the Cariboo Mountains, which even at the present day counts as almost unknown, but which was the scene of many persevering but unsuccessful endeavours to find a feasible route, the few lateral valleys being found to terminate in gorges, again to disappear in glacial sources at high altitudes. In the end the choice reverted to the southern route, the approach from the east being by way of Calgary and the Kicking Horse pass in the Rockies, while the Selkirks were successfully traversed by the Rogers pass, discovered so far back as 1866 by Moberly's assistant, Mr. Albert Perry. The more northern country has lately come again into notice in connection with the traverse of the mountains by the Canadian Northern and Grand Trunk Pacific Railways, the former of which adopts the route temporarily selected for the Canadian Pacific.

* Mr. Moberly acted under the general direction, as engineer-in-chief, of the late Sir Sandford Fleming. In a thin volume entitled 'The Rocks and Rivers of British Columbia,' printed in London in 1885, he gave an outline of his various exploring journeys, but only a limited edition seems to have been issued and the book is now difficult to obtain. A copy is, however, in the Society's Library. It contains a fairly detailed map.

Anthracite in Peru.

As in similar cases elsewhere, a result of the war has been to stimulate an interest in the undeveloped resources of Peru in anthracite coal, for which that country has hitherto depended largely on import, in spite of the extensive deposits known to exist within her borders. The Department of Ancachs has long been noted for its mineral wealth, and therein the Provinces of Pallasca, Huaylas and Yungay are those which offer most hopes of profitable exploitation. The coal deposits of these have lately been studied by a Peruvian engineer, J. M. Yáñez León, who gives a summary account of them in *Bulletin* No. 90 of the 'Cuerpo de Ingenieros de Minas del Peru.' He describes briefly the geology of the district in which the deposits occur—chiefly situated in the basin of the Huaraz river, known near its mouth as the Rio de Santa, which enters the Pacific at Chimbote near the town of Santa. A railway has already been carried from Chimbote along the course of the river for some distance inland, and is being extended still farther, past the town of Huaraz in its upper valley. The fundamental need for profitable development of the mines —that of easy transport—will thus be quickly supplied, at least as concerns the latter two of the provinces named, while for Pallasca a line has been proposed leaving the other at Chuquicara, at the mouth of the tributary of the Rio de Santa of the same name, and ascending the valley of that tributary in a northerly direction towards the province of Cajabamba. The opinion arrived at as to the possibilities of working the anthracite deposits is most favourable. It is pointed out that the use of this coal for domestic as well as industrial purposes is a growing one, and that the chief producing countries are more and more needing their own supplies for their own use. The coal is of good quality, and the detailed examination of the conditions of its occurrence leads to the conclusion that the supplies are practically inexhaustible. The sedimentary formations with which the beds are associated consist chiefly of quartzites and slates, the solid nature of which is favourable to the working of the mines, though on the other hand the scarcity of timber may prevent the winning of so large a percentage of the beds as might otherwise be the case. The formations in question show a perfect concordance of the strata for a distance ot more than 50 kiloms., and the dip is also favourable to easy working. The quartzites at the base of which the coal, with the associated slatey beds, occurs, date from the Wealden series of the Lower Cretaceous. Besides the coal, important deposits of tungsten occur in the province of Pallasca, and their exploitation has made favourable progress within the past dozen years.

AUSTRALASIA AND PACIFIC ISLANDS

The National Park of Tasmania.

The first annual report on the newly established Reserve in Tasmania which is to serve as a National Park was issued last year at Hobart. The park is under the management of a Board of twelve members appointed by the Governor in Council, who are jointly responsible for the report. Curiously this contains no precise definition of the locality in which the park is situated, but from the references to the natural features contained therein it appears that it occupies a tract in the County of Buckingham which has hitherto been little visited and has remained in a state of nature. It covers an area of 27,000 acres, or roughly the equivalent of a rectangle measuring 7 miles by 6, and is drained by the Russell Falls River, a western tributary of the Derwent—the river that debouches at Hobart. The western side is mountainous, and apparently

includes Mount Field East and its western neighbour known as Mount Field West or Humboldt, though the latter is not definitely referred to. Other features of interest are the Russell and Lady Barron Falls, and Lakes Fenton, Belton, and Belcher, the two last situated towards the south-west corner. The park has been partially fenced in, and as it is the sole sanctuary for the native animals and plants, every effort will be made to preserve them, though even the risk of penalties has not prevented attempts to hunt for game and skins. The prevention of bush-fires will also need careful attention. Access to the park is given by the Derwent Valley Railway, and it has already begun to attract visitors, for whose benefit tracks have been cut to the chief scenic beauties. At the time of its opening (13 October 1917) no suitable map of the area was in existence, but as a result of the work of several members of the Board a provisional map has been approved. Even this seems far from reaching the desirable degree of completeness and precision, and it is to be hoped that an accurate and detailed survey may be undertaken without undue delay.

An Ascent in the Solomon Islands.

By the courtesy of the Colonial Office we have been favoured with the copy of a despatch lately received from the British Solomon Islands describing the ascent by Mr. S. G. C. Knibbs, Crown Surveyor, of Mount Kolombangara (also written Kulambangra), a volcanic peak filling up almost the whole of the circular island of the same name lying off the north-western end of New Georgia. According to the Admiralty chart the highest point of the mountain reaches an altitude of 5156 feet, but even this is enough to make the ascent a matter of much difficulty under the conditions of climate and vegetation which prevail. Mr. Knibbs left Gizo (the station on the island of the same name west of New Georgia) in the Government launch on 8 September 1918, with eight natives attached to the Survey Department. He had with him a canoe in which, on reaching Kolombangara Island, he proceeded up the Vila or Stanmore River as far as was possible under the obstacles caused by rapids. It was hoped that the river-bed would permit an ascent through the gorge leading to the crater of the mountain, but heavy rain made the river a torrent and the only way of advance was by a main spur leading to the summit. It was necessary to cut a track through the bush practically all the way, and progress was difficult by reason of the mass of rotten vegetation covering the whole ground to a depth of about 2 feet. Pandanus grew in dense thickets, and even on the crest of the spur the surface was a veritable swamp in which the feet sometimes sank between the tree-roots knee-deep. Camping sites had to be improvised by the erection of temporary floors of saplings. The weather was constantly wet, and clouds obscured the view. The top was reached on September 12 by means of a very steep and razor-like spur, to the right of which lay the crater. The cold was so intense that no one slept the last night, it being impossible to obtain dry fuel for a fire. The trees on the top were stunted and of a different species to any seen lower down. All were covered with dripping masses of moss and lichen. In several places a tree with a leaf similar to a *Cinnamomum* and an aromatic bark was noticed, said by the native head-boy to be one called "kumanda," which grows on Ysabel. A bottle-record of the ascent was left in a crevice in the highest tree on the summit, and on the way down a similar record left by Mr. A. Mahaffy in 1901 was found in a tree. The descent was made with all speed, as the supplies were nearly at an end, and the natives were in an exhausted condition. Unfortunately Mr. Knibbs had no instruments with him, the opportunity of making the ascent having been unexpected.

GENERAL

Geographical Personnel in France.

The deaths during 1918 of several well-known French geographers have entailed changes in the personnel of more than one French geographical institution. Baron Hulot, who died in June after holding the office of General Secretary of the Paris Geographical Society for over twenty years, has been replaced by Dr. Guillaume Grandidier, son of the veteran explorer of Madagascar, and himself well known for his geographical work in and about the same island. He will be responsible for the part of the society's affairs which has to do with its *Bulletin* and other publications and with its external relations. The death of M. Vidal de la Blache, a notice of whom appeared in the *Journal* for July 1918, has necessitated a change in the geographical section of the 'Comité des Travaux Historiques et Scientifiques' at the Ministry of Public Instruction, of which the deceased was president. He has been replaced by our Honorary Corresponding Member, M. Henri Cordier, who consequently resigns the editorship of the useful publication of that department best known by its old title of *Bulletin de Géographie Historique et Descriptive*, but now merely entitled the *Bulletin* of the department in question. He in turn is succeeded as editor by M. Charles de la Roncière, head of the Department of Books, Maps, and Geographical Collections at the Bibliotèque Nationale. He is known for various excellent studies in the history of geography and colonization, including one on a previously unknown atlas illustrating Sir Francis Drake's last voyage preserved in the French National Collection (see *Journal*, vol. **36**, p. 363). Death has also removed a late colleague of M. Cordier, as editor of the valuable Orientalist publication T'oung Pao, in the person of the well-known Oriental scholar E. Chavannes. For the present the editorship remains in the capable hands of M. Cordier only.

Readership in Geography at Oxford.

It is announced that an election to the post of Reader in Geography at Oxford, which has been vacant since the death of Prof. Herbertson in 1915, will take place during the approaching academical term. The Reader, who will also be appointed Director of the School of Geography by the Committee of Geography, will be elected for a period of five years from 10 October 1919, and will be re-eligible. He will be required to lecture and give instruction in geography during seven weeks at least in each of the three University terms, and to perform such other duties as may be assigned to him as Director of the School of Geography. His stipend will be not less than £500 a year—£300 as Reader, £200 as Director of the School of Geography. Candidates must send in their applications, with such evidence of their qualifications as they may desire to submit, to the Assistant Registrar, University Registry, Oxford, so as to reach him not later than Saturday, May 17. Six copies, both of the letter of application and of testimonials, are to be sent, together with at least one copy of any published work to which it is desired to call attention.

Loss of Shackleton's Ship, the "Nimrod."

The "Marine Casualties" of Lloyds' list, 3 February 1919, contained the following:

> "*Nimrod*—Yarmouth (Nor.) Jan. 31.—Steamer *Nimrod*, of London, Blyth for Calais, with coal, touched the sand after passing Cockle light-vessel on Jan. 29. She again touched shortly afterwards and remained. Heavy seas broke over her and she started to break up

and fill with water, taking a heavy list to starboard. Her crew got into a boat, which was struck by a heavy sea and capsized. Only two men reached the shore, the remaining ten being drowned. The steamer was totally broken up."

The steamer thus unfortunately lost was well known as the vessel which carried Sir Ernest Shackleton and his party to the Antarctic in 1907. Built in Dundee in 1866 for Arctic whaling, she was purchased by Sir E. Shackleton from Messrs. Job Bros. in 1907, prior to which year she had been engaged in the Newfoundland sealing trade. She was entirely refitted in London for the Antarctic Expedition, and proved herself an exceptionally sturdy and suitable vessel for work in the Ross Sea. Before her departure from England in 1907 she was inspected at Cowes by H.M. King Edward VII. Her loss under such tragic circumstances will be mourned by the many who visited her, and most of all by those who sailed in her to the "thrilling regions of the thick-ribbed ice."

J. K. D.

A New Source of Turpentine Oil and Rosin.

The Imperial Institute calls attention to a new source of supply of these products, which are already being produced on a commercial scale in India by the distillation of pine rosin. The new source, which though comparatively small may be valuable, especially for Indian use, has been found in Indian frankincense or olibanum. This material is obtained by the natives by making incisions in the stems of *Boswellia serrata*, a tree widely distributed throughout the dry zone forests of Central India. The resinous substance which exudes from the cuts contains a kind of turpentine, a resin and a gum. Investigations of the methods of separating these constituents, their commercial uses and value, and the methods of tapping the tree, have been conducted since 1912 by the forest authorities in India in co-operation with the Imperial Institute, and the results have been published in a paper by R. S. Pearson, Forest Economist, and Puran Singh, Chemical Adviser to the orest Research Institute, Dehra Dun. The general conclusion is that the turpentine oil is equal to good quality American, and that it could be used in place of the latter in the manufacture of paints and varnishes. The rosin, too, would be quite suitable as a substitute for pine rosin (colophony) in the manufacture of varnishes.

OBITUARY

Theodore Roosevelt.

THIS is not the place to attempt anything like a general appreciation of the life and work of so outstanding a figure in the world's public economy as the late Mr. Roosevelt, but it would be unbecoming did we pass over his death without a brief expression of the loss thus sustained by this Society (which he honoured by accepting its Honorary Membership some twelve years ago), and a reference to the gains to geographical knowledge which resulted from his travels, though these were but an episode—and a recent one too—in his life of strenuous activity. Roosevelt's African travels and exploratory work in South America only a few years ago might in itself have been a claim to distinction in the case of a lesser man, but in his own it was largely overshadowed by his services in a wider field. It is for the leading part which he played in the reformation of public life in the United States by his fearless adherence to

principles, his downright honesty and determination, and sworn enmity to everything in the nature of a sham, that he will go down to history as one of the greatest forces in American public life in the opening years of this century.

Only a few of the outstanding facts of his life can here be recalled. Born in 1858, he came of a Dutch family, which had crossed over from Europe in the early days before the British became the possessors of New York, and on his mother's side was the descendant of a Governor of Georgia during the troubles with the mother country. Somewhat delicate in his youth, he was educated at Harvard, where he already displayed the bent towards Natural History which determined one of his recreations in later life. After studying law for a time, he entered the New York legislature in 1881 and soon made his mark as a determined foe of the corruption then reigning. Subsequently two years were spent on a ranch in North Dakota, and in 1889 he became a Civil Service Commissioner at Washington. Here and later as Police Commissioner of New York his fearless efforts again triumphed in the cause of reform. In 1897 he became Assistant Secretary of the Navy under President McKinley, and as such took a leading part in the American intervention in Cuba, whither he led a regiment of rough riders recruited by himself. As Governor of Albany in 1899 he showed his usual reforming efficiency, and in the next year he was associated with McKinley in the Presidential Campaign, becoming Vice-President under the latter as President. The murder of McKinley in 1901 raised him to the supreme position in the Republic, and during his two tenures of the office—he was triumphantly re-elected in 1904—he found a clear field for the determined but judicious carrying of his principles into action. His vigorous advocacy of the conservation of the national resources by forest protection, reclamation of desert lands by irrigation, and the like, is not the least of his claims to the gratitude of his countrymen. His leadership of a new party of "Progressives," which largely contributed to the Democratic success in 1912, and his strenuous advocacy of intervention on the side of the Allies in the European War, are matters of recent history. It will be remembered that his second son Kermit served with distinction with the British Army in Mesopotamia before being transferred to the American artillery on the entry of the United States into the war, and that his youngest son Quentin was killed in an air-fight during the Marne battle of 1918. His two other sons were both wounded.

It was after the close of his second Presidency that Roosevelt took advantage of the leisure thus gained to lead a scientific expedition to East Africa for purposes of zoological collecting and research. He went under the auspices of the Smithsonian Institution, accompanied by his son Kermit and three skilled zoologists, so that the results of the trip, which led through British East Africa, Uganda and the Nile country, were of considerable value. Roosevelt described his experiences in his book 'African Game Trails,' which gives a vivid idea of the African wilderness and its denizens—human and other. In 1913 he undertook a more ambitious journey, which resulted in a positive addition to geographical knowledge by the exploration of one of the few remaining blank spaces of any extent on the map of South America. The Brazilians under Colonel Rondon had already been busy in exploring the unknown ground on the western borders of Matto Grosso, and by combining forces with this explorer Roosevelt was able to take part in a thoroughly well-organized expedition which traced the course of a hitherto unsurveyed tributary of the Madeira River, besides making extensive zoological collections. After his return the ex-President, it will

be remembered, 'gave a vivid narrative of the work of the expedition at a meeting of this Society in 1914. In view of the somewhat extravagant claims made on his behalf by indiscreet admirers, it is well to remember that the traveller himself took a far more modest view of the extent of his achievement, and, as in the case of his African trip, bore generous testimony to the share of credit due to his various coadjutors. This expedition too was the subject of a thrilling narrative, 'Through the Brazilian Wilderness' (1914).

Roosevelt thus reversed the more usual order of things by becoming an explorer late in life after attaining fame as a statesman. But his sympathy with wild life and adventure was no newly developed trait, as is shown by his earlier studies of the westward expansion of the United States, of which his book 'The Winning of the West' (4 vols., 1889–96) gives a convenient and readable summary. Before this he had described his own experiences out West in 'Hunting Trips of a Ranchman' (1886) and 'Ranch-life and the Hunting Trail' (1888), and a complete list of his books would fill many lines of print. By so largely helping to make of the United States a World-power his work as a statesman may be said to have had an important bearing, too, on Political Geography.

Lieut.-Colonel Sir Mark Sykes, Bart., M.P.

Sir Mark Sykes, only son of the late Sir Tatton Sykes, was a traveller from early boyhood. In his book 'Dar-ul-Islam' he speaks of having been taken three times by his father to the Jebel Druse before he was fourteen, and of going again alone when eighteen. In the comparatively few succeeding years of his short life he made many more journeys to Asiatic Turkey, and in his several books, and the papers communicated to our own and to other societies, he displays the rare versatility, acute observation, rapid confident judgment and humour that made him the most amusing of companions and in latter days a most useful of counsellors. Full of enthusiasm for the genuine East, with all its disadvantages, he was unsparing in his dislike of the hybrid between East and West. His latest and most ambitious book—'The Caliphs' Last Heritage'—gave a brilliant sketch of history, followed by the diary of his later journeys, in which the town Armenian, the Young Turk, and all who show the results of contact with the West are dealt with pungently.

In 1902 he was gazetted to the Yorkshire Regiment, saw service in South Africa, and, with considerable intervals of leave for travel, was with the regiment until 1908. In 1911 he was elected to Parliament by Central Hull, and his occasional speeches on Eastern affairs were welcomed for the same qualities that distinguish his books: wide knowledge, trenchancy, and humorous good sense. Since the outbreak of the European War he had been employed with the Council of Imperial Defence and on several missions to the East, whence he had returned to Paris for the Peace Conference, where pneumonia following influenza killed him at the moment when his wide knowledge was employed in the highest and most intricate task that has ever faced geographers. His death at the early age of thirty-nine, in the fullness of his powers, is a tragic loss to our science, and leaves it but a speculation how much more he might have done with leisure to judge and perhaps to revise the brilliant impressions of the moment.

Elected a Fellow in 1907, he was in 1918 chosen for the Council, but was unable in the crisis of the war ever to take his seat. The deep sympathy of the Society will go out to his widow, a daughter of Sir John Gorst, and to his large family of young children. At the Requiem Mass sung in Westminster Cathedral

on March 26 the Council were represented by Sir Maurice de Bunsen and Colonel Sir Henry McMahon.

CORRESPONDENCE

The South Magnetic Pole.

As an observer who has carried out in the past a very large number of magnetic observations in Antarctic latitudes and as a student still of terrestrial magnetism, I have read with considerable interest Mr. E. A. Reeves' ingenious paper appearing in last month's *Journal* on "A Transformation of the Magnetic Dip Chart" and the discussion in connection therewith. In the report of the discussion on page 164 Mr. Hinks states, no doubt inadvertently, that Professor David had fixed the position of the south magnetic pole to within a few miles, and that he had some claim to be considered as an authority as "he is the only man who has made observations near it" (the magnetic pole). I think this statement is liable to be a little misleading.

Professor David, as we know, is a very eminent geologist, and he was probably in command of the small sledge party (Sir Ernest Shackleton's Antarctic Expedition) which set out towards the assumed direction of the south magnetic pole, but Douglas Mawson was the physicist of the party and the actual observer who carried out a series of magnetic observations near or in the approximate area of the south magnetic pole.

L. C. BERNACCHI.

Admiralty, 18 March 1919.

I am obliged to Lieut.-Commander Bernacchi for calling attention to the slip which I made in the discussion of Mr. Reeves' paper. Not only was Sir Douglas Mawson the magnetic observer with Professor David's party on the Shackleton expedition,[1] but on his own expedition in 1911–13 a further important contribution to the determination of the south magnetic pole was made by a sledge party in charge of Mr. Kidson, with Mr. Eric Webb as magnetic observer; and this should also have been mentioned.

A. R. H.

The Names of Himalayan Peaks.

Colonel Wauhope's letter is of considerable value as a contribution to the above problem, but one trusts that the names of the first and second mountains on the world's surface as regards altitude, will be reconsidered within the next few years, before a final decision is reached.

The name "Kinchenjunga," given by Colonel Wauhope, is an improvement on the Kinchinjunga appearing on maps after 1906, but in 1903 the name Kanchenjunga was used, so that the etymology has been obscured comparatively recently. Perhaps one might point out that Kang is the spelling of the Tibetan word for snow given by Mr. C. A. Bell, I.C.S., one of the best known British authorities on the language, but if "Gang" is more correct, it might be considered.

As regards Mount Everest, one ventures to hope that the name will not be definitely fixed until after the exploration of the group of mountains of which it is chief.

A. M. KELLAS.

7 April 1919.

Motor versus Rail in Persia.

In connection with the paper by Colonel Napier on "The Road from Baghdad to Baku," and subsequent discussion (*Journal*, January 1919), I should like to submit a few remarks on the subject of communications in Persia, which are of vital importance if ever trade on a large scale is attempted in that country. The reason motor transport is commercially possible in England is that we have good metalled roads, which reduce to a minimum the wear and tear on the vehicles employed. Without such roads this means of transport would never pay in any country. But good roads to stand heavy lorries cannot be made without water and suitable material. In the greater part of Persia water is very scarce and in some parts material is not available. The construction of suitable roads would therefore present considerable difficulties.

It is no argument in favour of the employment of commercial motors, which must pay their way, to point to what has recently been done in the matter of military motor transport. In war we are prepared, if necessary, to scrap fifty per cent. of our cars every few months, and think nothing of it. The kind of roads on which they run requires no water to make them, but they would be quite out of the question for paying commercial purposes. It is true that motors have gone from Quetta to Kirman, but I do not think any one ever thought of trying to make and maintain a commercially practicable motor road over the waterless and sandy tracts which separates these two places.

On the other hand the construction of railways presents little difficulty. For that reason I think it would be well to consider carefully the relative merits of both means of developing communications so badly wanted in Persia, and certainly in Eastern Persia the construction and maintenance of macadamized roads would be a difficult and expensive operation.

It is quite possible that suitable roads might be made in the better favoured parts of the country as feeders to railways, but in the desert areas, through which railways could be constructed, they would not be practicable, and you must pass through these to open up Persia, anyhow from the East.

It is sincerely to be hoped that the opportunity now presented to us of securing the trade of Persia will not be lost. We should lose no time in ascertaining the requirements of the people; sending samples of what we can supply and also obtaining samples of articles the people use which they formerly obtained from foreign countries. Goods of European manufacture have naturally become very scarce. I believe there is a great field for enterprise in this direction.

H. L. CROSTHWAIT, Lieut.-Col. R.E.

East Persia, February 1919.

The Maximum of Terrestrial Magnetization.

At the reading of Mr. Reeves's paper on "A Transformation of the Magnetic Dip Chart," printed on pp. 152–165 of vol. 53 of this *Journal*, I remarked on the strangeness of the fact that the maximum of terrestrial magnetization was in the direction of the great continental masses which were believed to be the regions where there is the greatest accumulation of non-ferruginous rocks—that is to say, where the material is least permeable to magnetism.

The explanation is, however, a very simple one. The interposition of a mass of permeable material in a magnetic field tends to concentrate the magnetic force in itself, leaving the adjoining space with fewer lines of magnetic

force. The ferruginous material almost immediately underlying the ocean would act in this way, leaving the surface above it badly provided with lines of magnetic force. The considerable depth of material forming the continents containing, as a rule, less ferruginous constituents, would not have this effect.

The lower temperature under the ocean would no doubt, as Dr. Chapman pointed out, have the effect of rendering the ferruginous material there more capable of magnetization, but susceptibility to magnetization at high temperatures must depend to a considerable extent on the pressure, and therefore on the depth. One would expect that under high pressures the limit of temperature at which magnetization is possible would be appreciably raised.

JOHN W. EVANS.

Imperial College of Science and Technology, 3 April 1919.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1918-1919

Fifth Afternoon Meeting, 17 March 1919.—Sir Aubrey Strahan in the Chair.

PAPER: Survey by Air Photographs. Lieut.-Colonel N. M. MacLeod, D.S.O.

Sixth Afternoon Meeting, 14 April 1919.—Sir Aubrey Strahan in the Chair.

PAPER: The use of the Astrolabe à Prisme. Dr. John Ball and Mr. H. Knox-Shaw.

Ninth Evening Meeting, 24 March 1919.—Mr. Douglas Freshfield, Vice-President, in the Chair.

ELECTIONS.—Lieut. W. Scott Bardwell; T. K. Mortimer-Booth; Lieut. Arnold Brougham Candler, R.E.; Rev. William Hodges Elwin, M.A.; Mortimer Epstein, M.A., PH.D.; Captain Frank M. Ford; Norman Edward Freakley; Lieut. C. Swinton Holland, R.N.; Thomas Winter Kennion; Major Edward Lyall, D.S.O.; E. J. Lloyd; T. R. Morgan; N. H. Norton, L.C.P.; Mervyn Grove Palmer; Charles Marisco Pearce; Lieut.-Colonel William J. T. Shorthose, K.A.R.; C. L. Woodhouse.

PAPER: A Contribution to the Geography of Macedonia. Captain Alan Ogilvie, R.F.A.

Tenth Evening Meeting, 7 April 1919.—Mr. Douglas Freshfield, Vice-President, in the Chair.

ELECTIONS.—Captain H. W. Cowling, M.C., R.E., B.SC.; Carlos H. Davila; Captain Cecil John Edmonds; Sidney Alfred Hall; Captain Charles Harvey Miller; Major Alan Leslie Morris; Captain J. A. Reid; William Arthur Rudd, M.A.; Lieut.-Colonel Charles Aitchison Smith; Captain Frederick John Thorpe.

PAPER: Poland. Miss Czaplicka.